JANUARY, 1984

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FRONT COVER

MAJESTIC *EUCALYPTUS* SHOWING ITS VIGOROUS GROWTH CHARACTERISTIC AT THE APPROACH ROAD OF THE CENTRAL SOIL SALINITY RESEARCH INSTITUTE, KARNAL (HARYANA)

Photo—M.M. Bahukhandi

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BACK COVER

FINE GROWTH OF *EUCALYPTUS TERETICORNIS* IN THE GAULA RANGE OF TARAI EAST FOREST DIVISION, HALDWANI.

Photo – V.K. Sharma

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NURSERY VIEW OF *EUCALYPTUS* SAPLINGS RAISED AT DADUPUR ON THE BANK OF WESTERN JAMUNA CANAL FOR VILLAGE EXTENSION WORK.

Photo—M.M. Bahukhandi

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THE INDIAN FORESTER

JANUARY, 1984

EDITORIAL

We take pride in informing our readers that Shri K.M. Tiwari, I.F.S., President, Forest Research Institute and Colleges, Dehra Dun and Vice Chairman, Board of Management of the *Indian Forester* has been honoured with the national award of 'PADMA SHRI' this year on the occasion of the Republic Day by the President of India. We congratulate him heartily for this distinction conferred on him.

* * *

This *Eucalyptus* Special-II issue is also devoted to various aspects of *Eucalyptus* cultivation and management in India. There are articles in this issue on experience with *Eucalyptus* in the States of Andhra Pradesh, Bihar, Haryana, Karnataka, Kerala, Maharashtra, Madhya Pradesh, Tamil Nadu, Uttar Pradesh and West Bengal.

* * *

The fact that *Eucalyptus* has capacity for 'Luxury Consumption' of water was mentioned in the opening paper of *Eucalyptus* Special-I issue (Tiwari and Mathur, *Indian Forester*, 109 : 851-860). This point is reiterated by the results presented by the authors on page 35 which shows that transpiration is a function of atmospheric aridity when soil moisture water conserving mechanisms are in operation in this species. Statements on transpiratory behaviour of *Eucalyptus* should, therefore, be made in conjunction with the amount of available soil moisture, failing which erroneous conclusions may be drawn.

* * *

As we enter our 110th year of publication, we have introduced a colour photograph on the front cover of this issue. It is proposed to continue with this, we request our readers to contribute suitable colour photographs/transparencies for our future issues.

With this issue we send our heartiest greetings to all our readers for a Very Happy New Year.

Hony. Editor

EUCALYPTUS IN ANDHRA PRADESH

A.L. RAO

Chief Conservator of Forests,
Social Forestry, Hyderabad (Andhra Pradesh)

Historical background

No definite date of introduction of *Eucalyptus* in Andhra Pradesh is available but *Eucalyptus globulus* appears to have been introduced on Horsely Hills (1463 m above mean sea level & M.A R. 75 cms) in Chittoor District, then a part of Madras presidency in the middle of ninteenth century, simultaneous with its introduction at Aramby Shola, near Ootacamund in Nilgiris. The single heavily branched *Eucalyptus globulus* tree that is now present on Horsely Hills attained 167.64 cm girth in 1917, 356 cm girth in 1962, and 432 cm girth and 43.5 m high in 1983.

The next dated record of *Eucalyptus* introduction in 1934 was again in Chittoor District on the Palamnair plateau, not far from Horsely Hills, and at an altitude of about 7t0 m and receiving an average annual rainfall of 650 mm. The species raised was *E. raudiana*, of which 13 trees are now present in Baireddipally and Mudivaripally Topes, which occur on the banks of streams with deep rich sandy loams. These trees now range in height between 25-40 m and B.H.G. of 160-270 cms.

The first attempt at planting *Eucalyptus* on a plantation scale was made in 1936 by R.B. Cornwell, then Divisional Forest Officer, Lower Godavari Division with *E. rostrata*, seeds of which were obtained directly from Australia. Nursery raised seedlings were planted out on sandy soils along with *Casuarina* in Kandikuppa along the coast at 7′ × 7′ (2.13 × 2.13 m) spacement. These were felled at the end of *Casuarina* rotation but allowed to grow as coppice while *Casuarina* was replanted.

In 1948 *E. rostrata* and *E. tereticornis* were tried on Sriharikota Island in Nellore District (5 m above sea level) receiving 960 mm rainfall mostly from North-East monsoons. These plantations did not fare too well and when measured in 1961-1962 :

E. rostrata	Girth 66 cm	Height 10.35 m
E. tereticornis	,, 67.8 cm	,, 10.66 m

In 1953 the so called *Eucalyptus hybrid* was first introduced in Zaheerabad block of Medak Division on deep lateritic soils in Soil Conservation plots in trenches 3′ × 1′ × 1′ the survivals were very poor and only 5 trees are surviving now with girths around 90 cm and 12 m height.

In 1954 "Mysore hybrid" was also introduced, with seed obtained from Mysore, on Sriharikota Island at 10 m × 10 m spacement. These attained by 1961 a girth of 63.5 cms. and 10.7 m height During the same period *E. rostrata* was also raised in Musalimadugu R.F. of Chittoor Division of which in 1960 there were only 14 survivals out of 1000 planted. This was followed by planting *E. hybrid* with seedlings obtained from Mysore in 1956 in Pattikonda R.F. of Chittoor West Division in 30 cm cube pits at 3.7 m × 3.7 m spacing and inter-cultivated with red-gram.

During the IInd five year plan period, nearly 2000 ha were brought under *E. hybrid* in the State with encouraging results. In the Godavari region where one of the earliest large scale planting was done at 8½′ × 8½′, 2 6 × 2.6 m) an average yield of 25 tonnes per ha was obtained at 12 years of age on clear felling. The stocking was however only 30%.

Research on *Eucalyptus* in Andhra Pradesh

It started first as vague exploratory trials on the initiative of individual officers. In 1958 the first systematic attempt was made at species trials when 15 species were planted on Sriharikota Island. The 15 species tried were *E. camaldulensis*, *E. citriodora*, *E. tereticornis*, *E. robusta*, *E. alba*, *E. cladocaly*, *E. ficifolia*, *E. grandis*, *E. pilularis*, *E. paniculata*, *E punctata*, *E. resinifera*, *E. rudis*, *E. staigeriana* and *E. viminalis*. Out of the above the first four fared well both in height, girth and survival. Apart from species trials, regular experiments were started in 1959 centering around (1) Techniques for artificial regeneration; (2) To gain knowledge on the behaviour of the species under varied climatic and edaphic conditions; and (3) To promote growth under adverse conditions. With these objectives in view research was in progress till mid-seventies, when the trend changed towards (1) Provenance trials of select species and (2) Genetic improvement.

This is what Late Sir H G Champion said in January 1962 about *Eucalyptus* research in Andhra Pradesh when on a visit to this State – "It is the best planned and executed set of comparative experiments with (mainly one 'form' the Mysore hybrid) *Eucalyptus* in India or elsewhere...... The experiments cover a wide range of practical issues, method of soil working and moisture conservation techniques, size of plants, application of manures and many other. All are replicated and care has been given to secure genuine comparability in nursery stock used and in other factors, neglect of which can vitiate results. In particular, seasonal vagaries have been covered by annual repetition over several years, a most important point for too often overlooked or neglected".

A summary of results of experiments done over the years is as follows :

Nursery trials : Investigations were mainly to determine—

(1) Type and size of nursery beds-sunken beds of 5′ × 4′ (1.52 × 1.22 m) dimension were found to be best for raising 2500-3000 healthy seedlings, with 2 Oz. (56.7 gms) seeds sown per bed.

(2) To control damping-off of seedlings—Treatment with red copper oxide, Zinc oxide or copper oxychloride in solution of (85 gms in 4.5 litres) water once every 2 days was found suitable and recommended.

(3) Method of sowing—It was suggested that bulking of seed mixed with sand gave a more uniform distribution of seed in beds. Further it was suggested that sowing in lines or furrows spaced uniformly was better than broad-casting.

(4) Watering of seed beds—It was found that covering of seed-bed with hay was a necessity till germination was completed in 4–7 days. It was also found that big drops of water falling from over 30 cm height would damage the seedlings, and watering needs to be done with a fine rosecan from below that height Watering was done at 3, 5 & 7 days interval, watering on wilting and no watering treatments were tried. Watering done with 36 litres per bed each watering day once in 5 days for inland areas was found suitable and economical. In sandy soils daily watering is recommended.

(5) Best time of sowing—Sowing was done on 25th of every month from October to February and seedlings were pricked out at 45 and 60 days intervals. The best month was found to be December and not later than mid-January. If taller seedlings are desired Oct.–Nov. sowings were found better. Pricking of seedlings when 45 days old was found better.

(6) Pricking out - It was found that after pricking out of seedlings from primary bed for planting in containers, giving a loop to the taproots prevents rapid development of taproot and encourages a bushy root-system which was found beneficial in planting out.

(7) Size and guage of polythene bags—Best survival and growth of seedlings was noticed in bags of 10 × 17.5 cm and 10 × 20 cm with both 100 and 200 guage. Best height of seedlings were obtained in 12.5 × 20 cm and 12.5 × 22.5 cms hence suggested where taller plants were desired.

Field trials : It includes investigation at time of planting and in later stages, also species and provenance trial.

(1) Best method of planting out :

(a) Complete removal of polythene bag gives better results than partial removal or only bottom removal.

(b) Best results are given by Rhombus corner moisture conservation device than saucer pit, trench & pit and sunken mound methods.

(c) In fertilizer trials in degraded soils, 40–60 gms NPK 17 : 17 : 17 gave best results.

(d) In termite control studies many pesticides have been tried, but no conclusive results are established as to the best pesticide and its dosage.

(2) Best season of planting—In coastal reasons receiving N.E. monsoons, September is best month and in inland regions July-August.

(3) Best season for coppicing – Summer coppicing was best being better than, during or immediately after rains.

(4) Coppice vigour—Studies were done with 2-6 coppice shoots, the best results are obtained with 2-3 shoots. In exceptional areas even 4 vigorous shoots are noticed as in Divancheruvu plantation near Rajahmundry and also in Zaheerabad.

(5) Soil working—Experiments have been done to study the effect of country ploughing, tractor ploughing and pit planting on establishment and growth. Tractor ploughing has given the best results on the degraded and badly eroded and hardened soil areas.

(6) Pests and diseases—Experts from Forest Research Institute visited about 20 plantations and reported that damage due to termites was secondary in nature in all cases the predisposing factor being loss of vigour due to other edaphic or climatic factors. However they noticed some damage due to root-shoot borer *Celosterne scabrator* in few seedlings and *Psiloptera fastucea* whose adults are defoliators while the larvae are stem borers in Sathupally plantations.

(7) Species trial—After the first trial in Sriharikota in 1958, subsequently 63 species (see appendix) have been tried at various places as follows: - Bapatla (11 spp.), Chagollu (19 spp.), Sarvepalli (19 spp.), Chitvel (20 spp.), Kandlamadugu (26 spp.) Araku (6 spp), Chintapalli (6 spp), Diwancheruvu (4 spp), Maredumilli (11 spp.), Muthyapalem (5 spp.), Yenagonda (12 spp.) in different parts of the State in different agro-climatic and edaphic zones. It has been finally concluded that *E. camaldulensis* and *E. tereticornis* are the best suited species followed by *E. microtheca* in drier zones, while *E. citriodora*, *E. punctata* *E. pilularis* *E. tesselaris* and *E. gummifera* are also fairly successful.

(8) Provenances trials—28 provenance of *E. camaldulensis*, 6 of *E. tereticornis*, and 7 of *E. microtheca* were supplied by *Eucalyptus* Research Centre, Hyderabad and are under trial in different centres in the State. So far the provenances doing well out of the *Eucalyptus camaldulensis* are of New Castle, Fortescue, Murtochison river, Bullock creek, Katherine, Petford, Isdells river, Lenard river, Grovie bank and Filenelors Richmond. In *E. tereticornis* 6 provenances are under trial of which Nos. 11953 and 10952 are fareing best. In *E. microtheca* No 4 is performing best Among the FRI hybrids IV & V, the latter is performing better but is not showing any uniformly good performance with reference to local selections.

(9) Tree Improvement—With a view to improve the future plantation being raised on a large scale in the State, seed production areas have been created in the State as per statement enclosed after removing the inferior trees in select plantations.

During 1982 & '83 seeds have been collected from 13 Plus trees from *E. camaldulensis* plantation in Kothagudem and from 37 *E. hybrid* trees from Wanaparthy, Rayadurg and Mulug plantations, and plantations are being raised in different centres using abvoe seed to form the nucleus of future "Seedling Seed Orchards" based on phenotypic characters. In the establishment of these seed orchards, selection has been made at all stages for best seedlings—at primary bed, in secondary bed stage, in polythene bags and ultimately, rogueing will be done. to remove the inferior stems in field. It is hoped that this procedure should enable a better seed source in the future.

To meet the needs of the above plantation work, good seed source is very essential. Hence 10 centres of seed production are being established covering all the agro-climatic and edaphic zones of the State where the seedlings are being raised from the plus trees with an eye on volume and quality. It is also proposed to collect seeds of plus trees from other states as well to increase the genetic diversity of the proposed seed orchards. At each of these 10 centres seed production areas of 10-20 ha each will be developed.

Attempts are now being made to raise seedlings vegetatively from plus trees under green-house condition at Araku and Chintapalli regions.

Performance of *Eucalyptus* in Andhra Pradesh

In 1975 the plantations have been evaluated in the State and were rated as mostly below Q. IV with reference to the All India Quality Classes suggested by Chaturvedi.

The plantations raised on sandy loams in regions below 900 mm rainfall have poor stocking from 20-60% and where good stocking is available has a wide variation in stem diameters, and yield about 6 m^3/ha M.A.I. at 10 years. In regions of higher rainfall, stocking is better, generally over 60%, and yield 10 m^3/ha M A I. and even more on better soils. Hence a felling cycle ranging from 10 years to 7 years has been suggested for areas receiving a rainfall of less than 900 mm to those over 1000 mm respectively The performance of *Eucalyptus* has been exceptionally good when raised under irrigated or partly irrigated conditions, in agriculture fields or on the bunds of fields.

Conclusion

Eucalyptus have an assured future in Andhra Pradesh, considering the large demand for the *Eucalyptus* wood for the industrial sector with 4 major pulp and paper mills, one rayon grade pulp wood requiring annually about 3.5 lakh tonnes of hardwoods and with expanding coal mining industry which also requires *Eucalyptus* poles as pit holes in a big way. For this reason raising of *Eucalyptus* plantations both in the public and private sectors to meet the increasing demand is expected to be profitable. The A.P. Forest Development Corporation

is currently planting annually about 7000 hectares mainly for use in the industrial sector, while several thousands hectares are also being planted with *Eucalyptus* annually in the private sector scattered practically in all districts of the State. The species most preferred are the Mysore hybrid *Eucalyptus* (*Eucalyptus tereticornis*) and the Jodhpur variety of *Eucalyptus camaldulensis* (original provenance not known). Species and provenance trials undertaken systematically by the research wing during the last few years have already shown some promising provenances of *Eucalyptus camaldulensis* for different agro-climatic zones in the State. It is expected that advantage would be taken of these results for introducing the successful provenances for raising plantations in the future both in the public and private sectors.

Provenances supplied by CSIRU through Eucalyptus Research Centre, Hyderabad.

E. camaldulensis	*E. tereticornis*
(1) Petford (N. QLD)	(1) Lake Land-downe
(2) Goodairs (NT)	(2) Kennedy River
(3) Katherine (NT)	(3) Black Mt.
(4) New Castle (NT)	(4) Mt. Frazer.
(5) Water Gilgandra (NSW)	(5) Mt. Molly.
(6) Ewenmor (NSW)	(6) Mitchel River.
(7) Creek Bullock (QLD)	
(8) Creek Barwan River (NSW)	
(9) Charlesville (QLD)	
(10) S. Quilpie (QLD)	
(11) Emmet (QLD)	
(12) Todd River (NT)	
(13) Ayers Rock (NT)	
(14) Agnew (WA)	
(15) Gnelisla (VIC)	
(16) Lennard River (WA)	
(17) Gwydir River Morse (NSW)	
(18) E. Fortescue (WA)	
(19) Hallscreek (WA)	
(20) Silverton Dt. (NSW)	
(21) Tumut River (NSW)	
(22) Murchison River (WA)	
(23) Wallpolla Island (VIC)	
(24) Lake Albacutya (VIC)	
(25) Isdell River (WA)	
(26) W. Dimbulah (N. QLD)	
(27) Quilpie (QLD)	
(28) Irvinbank (KN. QLD)	

List of species tried in Andhra Pradesh over the years.

(1) *Eucalyptus botryoides*
(2) *E. citriodora*
(3) *E. crebra*
(4) *E. behrima*
(5) *E. brockwayii*
(6) *E. tereticornis*
(7) *E. cladocalyx*
(8) *E. camaldulensis*
(9) *E. microcarpa*
(10) *E. gummifera*
(11) *E. punctata*
(12) *E. transcentenintalis*
(13) *E. salmonopholia*
(14) *E. salubris*
(15) *E. acameniodes*
(16) *E. leucoxylon*
(17) *E. mellidora*
(18) *E. maculata*
(19) *E. paniculata*
(20) *E. grandis*
(21) *E. cloeziana*
(22) *E. pilularis*
(23) *E. populnea*
(24) *E. ochrophloea*
(25) *E. naudiana*
(26) *E. tessellaris*
(27) *E. alba*
(28) *E. macrocarpa*
(29) *E. rummergii*
(30) *E. odontocarpa*
(31) *E. umbranarrensis*
(32) *E. socialis*
(33) *Eucalyptus brewifolia*
(34) *E. pachyphylla*
(35) *E. consideniana*
(36) *E. tasuranica*
(37) *E. St. Johnii*
(38) *E. fastigata*
(39) *E. nitens*
(40) *E. viminalis*
(41) *E. reguans*
(42) *E. decorticans*
(43) *E. saligna*
(44) *E. debrymploana*
(45) *E. sargentii*
(46) *E. argophoea*
(47) *E. blesseri*
(48) *E. rudis*
(49) *E. lonosera*
(50) *E. tetradonta*
(51) *E. deanii*
(52) *E. reesophylla*
(53) *E. delegatensis*
(54) *E. striaticalyx*
(55) *E. dunnii*
(56) *E. microtheca*
(57) *E. varmarocarna*
(58) *E. rostrata*
(59) *E. robusta*
(60) *E. globulus*
(61) *E ficifolia*
(62) *E. resinifera*
(63) *E. straigeriana*

Seed Production Area and Plus Trees.

Agro-climatic zone	Place	Year	Area	No. of trees in seed production area	No of Plus trees
1	2	3	4	5	6
Northern Coastal Region.	Dubbicherla	1960	—	—	5
	Tadakapudi	1971	20	—	30
	Darbagudem	1970	—	—	113
Northern High Altitude.	Araku	1966	—	—	75
Krishna-Godavari Region.	Nallagula	1959	30	—	15
	Nallagula	1960	—	—	5
	Burrenkalapadu	1959	—	—	41
	Burrenkalapadu	1960	8.0	—	84
	Sattupally	1961	—	—	11
		1962	—	—	14
		1968	—	—	8
		1969	—	—	9
Southern Region.	Mogilipenta	1963	—	—	9
	Kesapuram	1963, 1964, 1965	6.0	425	—
	Tirumala	1968	4.0	468	—
Rayalaseema Region (Euphorbia Region)	Rayadurg	1971, 1972	—	994	59
Central and Southern Telangana.	Wanaparthy	1965, 1966, 1967, 1968	4.5	1340	46, 13
	Anantagiri	1971	4.0	—	—
	Mulug	1965	—	—	11
Northern Telangana.	Kothagudem	1977	—	—	13 *E. camaldulensis*
	Lothuvagu	1967	—	—	11

EUCALYPTUS IN RECLAMATION OF SALINE AND ALKALINE SOILS IN INDIA

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The Saline and Alkaline soils cover nearly 7 million ha of land occurring in as many as 14 states of India. These soils are of the intrazonal order as these develop under the operative influence of local soil forming factors. Occurring as vast intrusions of barren lands completely devoid of vegetation, they are found primarily in (1) Valleys and basins of Western India, (2) Ganges valley West of 80° longitude, (3) Uplands of the Deccan plateau between the Tapti, Godawari and Bhima rivers, (4) Saline marshes, sea coast and the deltas of the Ganges, Cauvery, Mahanadi, (5) Coastal flats along the Rann of Kutch. These saline soils represent a group of soils which are characterised by occurrence of a high proportion of soluble salts usually chlorides and sulphates of the alkali bases The electrical conductivity of these soils is usually 4 mm hos/cm and their pH is in the range of 8.0 to 8 50. The soils affected by alkali have a high pH which may range between 9 0 and 10.5 and the exhangeable sodium may be over 15%. In these cases the physical condition of the soils is affected considerably due to disperation of the Clay colloides which affect their fertility status and cropping capacity. Limited availability of air and moisture and toxicity of the soils affect the plant survival to an extent that raising of food or tree crops in such areas presents numerous problems. Importance of afforestation of these areas which occur as vast treeless zones need not be over emphasized. Any tree growth in these areas will be of immense value in meeting the demands of local people for small timber, fuel and pasture land. Their aesthetic and recreational values are also of great significance. *Eucalyptus* species which have been successfully tried in Uttar Pradesh, Haryana and Tamil Nadu and various other states of India have demonstrated their capability of yielding higher biomass in a shorter period than any other indigenous species and have popularised themselves as easy growing multipurpose ornamentals in varied range of climatic and edaphic complexes in India. The experimental trial of *Eucalyptus hybrid* has revealed that *Usar* soils with good drainage and pH up to 8 5 could be afforested by planting in pits Soils with pH varying between 8.: to 11 0 usually associated with poor drainage and *Kankar* pan can be afforested by planting in deep pit with soil replaced by non-*Usar* soils. Leaching of soil though slightly improved the growing conditions, yet mortality was too heavy. Addition of gypsum and farmyard manure as soil correction gave better results. *Eucalyptus hybrid* (*E. tereticornis*) put up faster growth.

Much work is still required to be done regarding utilization of these soils for afforestation. A scheme for utilization of these soils for afforestation was initiated in 1963-64 and continued till 1970-71. An area of 264 ha was planted in Karnal Forest Division. Pits of

60 cm × 60 cm × 60 cm were used for planting. Use of good soils from outside was made over a limited area. Mounds about 30 cm high were made on sites subject to flooding during monsoon. Planting was done with *Eucalyptus hybrid*, *Prosopis juliflora* and *Acacia nilotica*. The Scheme was discontinued. Limited experience gained during afforestation of these soils showed that (i) *Eucalyptus hybrid* can be grown with moderate success if the salt content is not more than 5-8% or so, (ii) Some degree of reclamation by use of soil amendments is essential before planting, (iii) Shade of trees is helpful in preventing upwards movement of salts.

In areas of low rainfall, e.g. 255 mm (10″) mean annual and fairly uniform distribution e.g. no months with less than about 13 mm (0.5″) and rarely exceeding 25 mm (1″), there are some western Australian species which tolerate or even appear to prefer alkaline soils conditions :

Group 1 – Salt Tolerant

E. dundasi	*E. occidentalis*

Group 2 – could be tried where rainfall is higher, e.g. 380–635 mm (15-25″).

E. bicolor	*E. ochropholia*
E. botryoides	*E. pilligaensis*
E fasciculosa	*E. populifolia*
E microtheca	

Adaptability trials were carried out in two different environments viz., Jodhpur and Pali. It was observed that the species with wide latitudinal distribution and belonging to the summer rainfall region in their native habitat have done well compared to the species with narrow latitudinal distribution and belonging to winter rainfall areas. In general, *E. melanophloia*, *E. terminalis* and *E. camaldulensis* proved to the most promising species and are recommended for large scale species elimination trials in the region. In calcareous soils *E tesselaris* showed promising performance. The defferential growth and development exhibited by different species in the two habitates suggest a need for studying the correct mycorhizal fungus in the establishment and growth of the species.

E hybrid, *E. melanophloia*, *E. camaldulensis*, *E. tereticornis* and *E. rudis* have been tried with success in sandy, saline and arid tracts of Punjab with irrigation facilities for the first three years. *Eucalyptus melanophloia* is a good species for its heavy, strong and durable timber

Trials with *Eucalyptus* have received considerable attention during the last five years in India in view of the ambitious plans to afforest large areas of barren waste lands in different parts of the country. The land is particularly acute in the low rainfall zone which also carries heavy human and cattle population and has been subjected to maximum deforestation and soil degradation. Another object of these trials is to discover useful exotic tree species which could advantageously replace growth of low economic value.

A very large number of *Eucalyptus* have been introduced in Rajasthan on shallow soils (15 cm in depth) overlaying hard calcareous *pan*. In such habitats experiments on soil working have been shown that unless the pan is perforated to a depth of atleast 1 metre good growth of any tree species is just not possible. By following this soil working technique the most promising *Eucalyptus* species found are *Eucalyptus tesselaris, E. melonophloia, E. cooleba, E. oleosa, E. ochrophloia*, and *E. brevifolia*. Of these *Eucalyptus oleosa* is one of the mellea (a small tree). *E. oleosa* is confined mainly to lower slopes of lime stone hills (Kaul, 1968).

The fast growing nature of *Eucalyptus* has attracted the Punjab farmers to take up its planting on their farms. There is a great demand for *Eucalyptus* plants by the farmers throughout the year for raising wind breaks along their fields. The forest department is supplying *Eucalyptus* seedlings to the villagers at nominal rate of 10 paisa per plant from its nurseries. *Eucalyptus* planting along the farms has an advantage over Shisham, Siris etc. because it does not provide shade to the agricultural crops, attracts less birds and owing to its deep root system does not stand in competition with the agricultural crops. It provides wood to the village community for domestic use, particularly for fuel purposes, thereby relieves cow dung manure for agricultural fields. When *Eucalyptus* wood would become available in large quantities agricultural production programmes will benefit from it. In addition rural electrification programme will be provided with poles for electric installation thereby helping in setting up of tube wells for irrigation to increase yield from fields. Wind breaks and shelterbelts of *Eucalyptus* will reduce damage caused by strong, wind storms and desiccating hot winds during summer. Hence *Eucalyptus* planting has revolutionised forestry in Punjab plains. In Punjab plains loam and sandy loam soils with good drainage have given the best results whereas defectively drained soils having high clay content and occasional alkali *pan* formation and other adverse physical conditions have reflected in poor growth of *Eucalyptus* plants. Proper care in the early stage of seedling like watering in dry months helps in better growth of the plant. The first growing season is the critical period for the young plants. Plants respond well to soil working, manuring and watering very significantly Ordinarily frost has no significant effect on growth, but heavy continuous frost adversly affects the growth. In shallow soils especially with *Kankar pan* or gravel river beds and closer spacing, plants attain more height in proportion to girth. During strong winds and dust storms particularly in case of areas having shallow soils or high water table an appreciable damage occurs on account of toppling of trees. Flow irrigation has marked effect on the growth of the plants especially in alkali and saline soils, where it helps in downward leaching of salts.

In case of waterlogged and alkaline soils the performance of *Eucalyptus* has not so far been very encouraging. Similarly where soils have been washed off nutrient content by frequent flooding the growth *Eucalyptus* is satisfactory. For such areas some resistant strains are to be developed by breeding methods. *Eucalyptus hybrid* has given promising results in flood plains in Punjab and on canal banks at Aligarh (rate of growth 2.3 yr/yr).

Need for provenance trial. With the species of which the stage of elimination trials is over, and having selected the successful ones, the next stage is to conduct extensive provenance trials of the same from authentic seeds from areas of natural occurrence to select the superior genetic material within the species. This is urgently called for with atleast two species viz. *Eucalyptus tereticornis* and *E camaldulensis*, which have already done well in India; but of which many provenances occur in Australia, and it would be well worth of effort to find out if some better provenance is available for different sites on the same site. For calcareous soil which present a great problem to afforestation in India a provenance of *E. camaldulensis* from calcareous sites in its natural home (Australia) is worth for procurement.

Eucalyptus planting cannot produce as fully as possible unless supported by continuing trials and research. This should cover a range of conditions leading to tree improvement by the application of genetic principles and various modifications in growing methods. New strains of *Eucalyptus* varieties resistant to salinity and alkalinity of soil should be evolved by hybridization (inter specific hybrid). Procurement of seeds, of additional species and their trials should be given top priority. Incorporation of gypsum + F.Y M. in the soil of the planting pit is helpful in improving the conditions of alkali soil (Yadav and Sharma, 1976), Pyrite and acid forming amendment can also be used beneficially (Luthra, 1980). Several methods of soils working and planting techniques may also be used to obtained good results (Yadav, 1980; Ghosh, 1977; Yadav and Singh, 1970). A technique of growing plants in auger holes to bypass the roots through barriers of these soils may be used. *Eucalyptus* species like *E. hybrid* and *E gomphocephala* may be planted first time after adding suitable amendments and then in second rotation may be switched to other local but tolerant species such as *Madhuca longifolia*, *Diospyros melanoxylon*, *Terminalia arjuna*. *Albizia procera* etc. (Samra *et al* 1980). The growth of *Eucalyptus hybrid* has been found satisfactory on soils having pH below 9 and soluble salt content up to 0 3%, whereas it fails to grow on soils having pH above 10 and soluble salt content higher than 0.7%. Ground gypsum 4.5 kg. with 3 kg. of FYM per plant is used to improve soil conditions to establish and promote plant growth. Application of 200 gms of Ammonium sulphate with 400 gms of single super-phosphate per plant at the time of planting has been found useful to help the growth of plants

Site selection. A careful selection of site is essential. The site should be classified on the basis of the existing vegetation as (1) Completely deteriorated - such sites are barren and do not carry any shrubs or trees, (2) Severely deteriorated—these sites carry sporadic trees and shrubs like *Salvadora aleoides*, *Capparis decidua* and *Prosopis cineraria* etc. interspersed with big patches of barren lands, (3) Moderately deteriorated—such sites carry patches of *Desmostachiya bipinnata* mixed with shrubs like *Capparis horrida* etc. The sites of 2nd and 3rd category are used for afforestation.

Selection of species. Before selecting species for a particular site, the existing vegetation is listed to classify the site to indicate the degree of salinity and alkalinity for guidance of field staff

Eucalyptus camaldulensis has been reported to give good results under saline water irrigation in French sahara (Karschon, 1966). In Sudan, irrigated plantations of *E. microtheca* have been established on salt affected vertisols (Jackson, 1977). In Kuwait plantations with *Eucalpytus camaldulensis* have been raised in saline soils. *E. camaldulensis* from Kuwait origin on Saline sites has been found to exhibit faster growth, better form and greater hardiness than its counterparts from other regions (Raja Singh, 1965) *E. gomphocephala, E. obtusa* have also been successful on salt affected soils. In Israel, *E. camaldulensis* have been successful on Solonchak seep soils (Karschon, 1966).

At Igli area in the French sahara *E. occidentalis* have been tried with success. At Hassi Messaoud, *E camaldulensis* has given good results under irrigation with water containing. 1.700 ppm total dissolved salts with 20 ppm cl. applied at the rate of 15,000-27,000 m³ per ha per year (Karschon, 1966). Until the mid 1960s there was little research aimed at making use of genetic variation to improve the yield and quality of *E. camaldulensis* plantations. Eldridge, K.G 1975 reported provenance trial of this *Eucalyptus* in his bibliography, based mainly on the authenticated seed collection made by the Forestry and Timber Bureau, Australia, with the support of the F.A.O. of the United Nations since 1966 Early results of these trials have shown that some less well known provenances produced much more wood than commonly used provenances. Genetic variations demonstrated in provenances trials shows this highly variable species to have genetically adapted to the wide range of sites on which it grows in Australia. The masses of data accumulating and the variable forms of reporting results indicate an urgent need to prepare a consolidated account of the variation of the species provenance. Salt and alkali resistant provenances of this species need further exploration.

SUMMARY

The Saline and Alkaline soils cover nearly 7 million ha of land occurring in as many as 14 states of India. It is indeed a challenging task to afforest these areas since most of the indigenous and exotic species are not tolerant of soil alkalinity and salinity. *Eucalyptus* plantation programme has gained momentum during the recent past under social forestry and farm forestry programmes. *Eucalyptus* are easy to propagate and require little care. Their rate of growth and biomass production is high and has attracted the attention of foresters as well as the general public. Barren lands have been considered best for planting fast growing adaptable exotic and indigenous species. Many *Eucalyptus* species and their salt resistant provenance may be of utmost importance for afforesting the salt affected and alkalinity affected soils in various regions in India. More genetical research is essential to locate suitable provenances to plant them in these salt and alkali affected areas. *Eucalyptus* species growing in the homoclimatic zones in Australia under saline and alkaline soils may prove of great help in successfully afforesting such tracts in various regions of India. The climatic, ecotypic and soil conditions of the environment where these species or their strains occur in Australia needs thorough study. Studies are also required to discover and locate identical locations in India for trying these species and strains of *Eucalyptus*. *Eucalyptus camaldulensis* is a potential species

for this purpose and its new provenances and strains need exploratory research. It is advisable that under seed exchange programme more stress should be laid on procuring seeds of such available provenances of *E. camaldulensis* which occur in sailne and alkaline soils in Australia. Inter specific hybridization for evolving salt and alkali resistant strains of *Eucalyptus* is expected to ease the problem of afforestation in saline and alkaline soils.

भारत में लवण व क्षारमृदाओं के सुधार में युकेलिप्टस

लेखक एन०के० माथुर व ए०के० शर्मा

सारांश

भारत में 14 राज्यों भर में फैली हुई लगभग 70 लाख हेक्टेयर भूमि लवण और क्षारीय हैं। इन क्षेत्रों में वन लगाना निस्सन्देह चुनौती भरा कार्य है क्योंकि अधिकांश देशी और परदेशीय वृक्ष जातियां मृदा क्षारीयता और लवणता सहिष्णु नहीं हैं। विगत वर्षों में सामाजिक वानिकी और कृषि वानिकी कार्यक्रमों के अन्तर्गत युकेलिप्टस रोपने के कार्यक्रमों में वृद्धि हुई है। युकेलिप्टस प्रवर्धन सरलहै तथा उन्हें देखभाल की भी जरूरत नहीं पड़ती है। उनकी वढ़वार और जैवपुंज उत्पादन भी ऊंचे हैं तथा वानिकों और सामान्य जनता सभी का ध्यान इन्होंने आकर्षित किया है। शीघ्रवर्धी अनुकूलनक्षम परदेशीय और देशी जातियां रोपने के लिए बंजर भूमियां सबसे अच्छी रही हैं। भारत के विभिन्न क्षेत्रों में लवण प्रभावित और क्षारीयता प्रभावित क्षेत्रों के वनीकरण के लिए युकेलिप्टस की अनेक जातियां तथा उनके लवण प्रतिरोधी स्थानजभेद बहुत महत्व के सिद्ध हो सकते हैं। लवण और क्षार से प्रभावित इन क्षेत्रों में लगाने के लिए उपयुक्त स्थानज भेद ज्ञात करने के लिये और अधिक आनुवंशिक अनुसन्धान किया जाना आवश्यक है। आस्ट्रेलिया के समान जलवायु क्षेत्रों की लवण और क्षारीय मृदाओं में होने वाली युकेलिप्टस की जातियां भारत के विभिन्न प्रदेशों के ऐसे क्षेत्रों में सफलतापूर्वक वन लगाने के कार्य में बहुत सहायक सिद्ध हो सकती है। आस्ट्रेलियाई पर्यावरण की जलवायु, वासप्ररूप और मृदा अवस्थाओं का जहां ये जातियां या इनके विभेद होते हैं, भलीभांति अध्ययन करने की आवश्यकता है। युकेलिप्टस की इन जातियों और प्रभेदों पर परीक्षण करने के लिए भारत में उन जैसे स्थानों को खोजने और नश्चित कराने के अध्ययनों की भी आवश्यकता है।

इस प्रयोजन के लिए युकेलिप्टस कैमेलड्यूलेंसिस संभावनाओं वाली जाति है। तथा इसके नये स्थानज भेदों और प्रभेदों पर खोजपरख गवेषणा की जानी चाहिये। बहुत वांछनीय है कि बीज विनिमय कार्यक्रमों में यु० कैमेलड्यूलेंसिस के ऐसे उपलब्ध स्थानभेद मंगाने पर ज्यादा जोर दिया जाए जो आस्ट्रेलिया में लवण और क्षारीय मृदाओं में होते हैं। युकेलिप्टसों में लवण और क्षार प्रतिरोधी प्रभेद विकसित करने के लिए अन्तर जातीय संकरण कार्य से लवण और क्षारीय मृदाओं में वन लगाने की समस्या सुलझाना भी सुगम हो जायगा।

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IMPACT OF GROWING *EUCALYPTUS* AND SAL MONOCULTURES ON SOIL IN NATURAL SAL AREA OF DOON VALLEY

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The monocultures of fast growing, short rotation forest spp. are becoming universally accepted afforestation practice. To raise the production of fuel, timber, pulp etc., the *Eucalyptus* because of its astonishing growth characteristics and eco-adaptability has proved its superiority over the other forest spp. in India. The demand of forest products is escalating pressures on the natural forests and maintainance of high soil fertility levels and environmental quality have become evermore significant to foresters. *Eucalyptus* has been high recommended for various forestry programmes such as Agroforestry, Social Forestry, Farm Forestry etc. In the recent past, there has been a controversy over the large scale *Eucalyptus* plantation in the country. Since not many studies have been made on the impact of *Eucalyptus* monoculture on soil properties, the present investigation was undertaken to study the impact of growing *Eucalyptus* and Sal monocultures on soil of the Doon Valley by comparing it with the soil conditions under natural Sal forest.

Experimental

Location of the study. This study was conducted in *Eucalyptus camaldulensis* and *Shorea robusta* monocultures in the Demonstration Area of F.R.I. and natural Sal (*Shorea robusta*) forest at Asarori in West Dehra Dun Forest Division.

The area under study has a tropical monsoon climate with a conspicuously long winter period and humid monsoon season of about 4 months. The average annual rainfall is about 2079 mm. The area is characterised by high temperature which ranges from 4°C in December to 35°C in May. The mean summer temperature is about 25°C and the mean winter temperature is about 13.3°C.

The study area is located on an interfluves, consisting mainly of fluviatile sedimentation. The soils have been developed in the old alluvium received from Siwaliks and Himalayas. They have undergone the effects of leaching for a longer time leading to the formation of B2 horizons. Soils of this area mainly correspond to Typic Paleudalfs in the comprehensive system of soil clssification (7th Approximation).

Methodology

One plot was used in each monoculture (*Eucalyptus camaldulensis* and *Shorea robusta*) and one in natural Sal (*Shorea robusta*) forest for soil sampling. Soil profile pits were exposed

on the representative sites and soil samples were collected from predetermined depths of 0–15, 30–60, 60–90, 90–120 and 120–180 cm. The morphological features of the sites were also recorded.

The soil samples were air-dried and passed through 2 mm sieve for laboratory investigations. Soil samples were analysed for mechanical composition using hydrometer method, water holding and field capacity by standard method as described by Black (1965). Soil pH was determined in 1 : 2.5 (soil : water) suspension using glass electrodes. Organic carbon was determined by Walkely and Black's method (Piper, 1950). Total and available nutrients were analysed by the standard methods (Jackson, 1967 and Black, 1965).

Results and Discussion

The experimental results on the physico-chemical properties under the *Eucalyptus camaldulensis*, *Shorea robusta* monocultures and natural *Shorea rubsta* forest have been presented in Table 1. Loss and gain in soil properties in the soil profile under *Eucalyptus* and Sal monocultures and their comparison with natural Sal have also been worked out and reported in Table 3.

The soil texture varies from clay to clay loam under *Eucalyptus*, clay loam to loam under Sal monoculture and silty loam to loam under natural Sal forest. This indicates a close similarity in the textural class of the soils under investigation. The variation in the clay content has affected the water holding and field capacity of the soils. The moisture retention capacity has been observed to be maximum at the surface under natural Sal followed by *Eucalyptus* and Sal monocultures. The role of Organic matter is significant as maximum accumulation of Organic matter has occurred under natural Sal followed by *Eucalyptus* and Sal monoculture. As far as accumulation of Organic matter is concerned, *Eucalyptus* has proved to be better species in comparison to Sal monoculture, which is older than the former.

Significant changes in physical and chemical parameters of the soil occur as a result of tree planting, at or near the surface and are related to the supply of Organic matter from the leaf litter (Page, 1968). None of the monoculture (*Eucalyptus* or Sal) could surpass natural Sal in accumulation of Organic matter. Table 2 indicates that the Organic matter content up to 90 cm depth soil profile under *Eucalyptus* and Sal monocultures are fairly low as compared to natural Sal taken as 100, although the Organic matter content under the *Eucalyputs* monoculture is closer to natural Sal in comparison to the Sal monoculture. Fast growing *Eucalyptus* has a tendency to return more Organic matter to the soil in comparison to slow growing tree species i.e., Sal monoculture. Since Organic matter has over riding effect on soil fertility, the other soil properties would also be closely related with it.

The *Eucalyptus* monoculture has shown a substantial increase in soil pH as compared with the natural Sal, however, Sal monoculture has resulted in a decrease in the soil reaction. Chijicke (1980) has reported in Nigerian *Gmelina* plantations which were of younger age classes resulted in an increase in soil pH campared with natural forest. The *Eucalyptus*

Table 1

Some Physico-Chemical properties of the soils under natural Sal, Sal and Eucalyptus monocultures

Description of the Site	Depth (cm)	Mechanical Composition (%)			Textural Class	Maximum water holding capacity (%)	Field capacity (%)	pH	Organic matter (%)
		Sand	Site	Clay					
Shorea robusta	0–30	49.42	26.99	23.59	Silty loam	53.18	20.40	.2	4.52
Natural,	30–60	3.54	22 88	23.58	Loam	41.71	13.40	6.2	1.86
Asarori, Dehra Dun	60–90	51.84	22.72	25.44	Clay loam	35.29	9.10	6.2	0.83
	90–120	53.80	18.68	27.52	Clay loam	39.84	11.90	5.9	0.45
	120–180	62.21	18 55	19.24	Loam	39.75	11.90	6.1	0.40
Shorea robusta	0–15	62.28	18 33	19.39	Loam	34.01	16 39	5.4	1.31
Monoculture,	15–30	59.53	19.65	21.82	Loam	32 87	16.97	5.8	1.17
1926 Plantation,	30–60	51 36	20.68	27.96	Clay loam	43 79	22.17	5.9	1.44
D.A., New Forest,	60–90	51.05	22.89	26.06	Clay loam	40.77	22.46	6.0	1.58
Dehra Dun	90–120	63.76	16.55	19 69	Loam	32.32	19.48	5 8	1.03
	120–180	63.99	16.44	19.57	Loam	34.38	19.23	5.7	1.24
Eucalyptus camaldulensis	0–15	50 20	23 12	26.68	Clay loam	36 68	19.92	6.3	1.89
Monoculture,	15–30	37.72	23.15	39.13	Clay loam	43.16	23.60	6.4	1.62
1967 Plantation,	30–60	33.38	21.14	45.48	Clay	46.47	25.93	6.6	1 79
D.A., New Forest,	60–90	41.56	21.19	37.25	Clay loam	47.91	27.53	6.9	1.68
Dehra Dun	90–120	43.39	21.08	35.53	Clay loam	46.65	25.00	6.8	1.37
	120–180	46.61	18.79	34.60	Clay loam	46.06	22.90	6.8	1.10

Table 2

Relative soil nutrients (tons/ha) under natural Sal. Eucalyptus and Sal monoculture

Species	Depth (cm)	Organic matter	Total nutrients			Available nutrients		
			N	P_2O_5	K_2O	N	P	K
Shorea robusta	0–60	255 2	10.8	7.1	20.2	1.2	0 3	1.3
Natural,	60–120	51.2	2.9	1.4	33.7	0.6	0.1	1.3
Asarori, Dehra Dun	120–180	32.0	1 6	1.0	33.7	0.2	0.2	0.6
Shorea robusta	0–60	107.2	5.0	0 8	21.2	0.7	0.2	0.3
Monoculture, 1926 Plantation,	60–120	104.4	4.6	0.7	14.4	0.4	0.1	0.2
D.A., New Forest, Dehra Dun	120–180	99.2	4.3	0.7	15.8	0.3	0.1	0.2
Eucalyptus camaldulensis	0–60	141.8	6.7	3.0	29 0	1.0	0.2	0.3
Monoculture, 1967 plantation,	60–120	122.0	5.3	2.2	51.8	0.8	0.2	0.2
D.A., New Forest. Dehra Dun	120–180	88.0	4.4	1.8	48.0	0.5	0.3	0.3

Table 3

Loss and gain in soil properties down the soil profile under Eucalyptus and Sal monoculture when compared with natural Sal taken as 100.

Species	Depth (cm)	Clay content	Field capacity	Organic matter	Total nutrient			Available nutrient		
					N	P_2O_5	K_2O	N	P	K
Shorea robusta	30	−9	−24	−75	−66	−87	50	−50	−29	−76
Monoculture,	90	8	43	−35	−30	−88	−31	−37	−24	−79
1926 Plantation,	180	−17	90	133	119	−61	−61	0	−29	−75
D.A., New Forest,										
Dehra Dun										
Eucalyptus camaldulensis	30	62	2	−62	−54	−36	175	−21	0	−81
Monoculture,	90	78	82	−24	−12	−16	15	5	−17	| 77
1967 Plantation,	180	42	131	167	127	195	−91	83	27	−81
D.A., New Forest,										
Dehra Dun										

monoculture in the present investigation is fairly young (14 years) in comparison to Sal monoculture. Chijicke (1980) has further reported that soil pH increased during the first five years of afforestation and begins to decrease again from the 6th year almost returning to the natural forest situation at the 20-40 cm level by the 13th year of *Gmelina* growth.

It is evident from the analytical results that total nitrogen and phosphorus are high in *Eucalyptus* monoculture in comparison to Sal monoculture. The contents are more distinct at the surface. Due to abundance of Organic matter under natural Sal forest the nitrogen and phosphorus are fairly high at the surface. The total potassium shows a reverse trend. It is highest under *Eucalyptus* than Sal monoculture. It is noted that the total potassium level has surpassed even the natural Sal at the surface soil. The differences could be due to the differential behaviour of *Eucalyptus* in utilising the fixed potassium from the lower soil horizon (Table 2). Almost similar trend was noticed in the distribution of available nitrogen and phosphorus in the soil, however, the available potassium is higher under Sal monoculture as compared with *Eucalyptus* monoculture. None of the two monocultures could exceed the natural Sal as far as available potassium is concerned.

From these observation, it is indicated that raising *Eucalyptus* monoculture in natural Sal forest area is not deliterious as it caused no damage to the soil in comparison to Sal monoculture within the given experimental conditions. This will also help in bridging the gap between the demand and supply of the raw material to various wood based industries besides meeting the local demand of wood in a shorter period of time.

Conclusions

The study on physical and chemical properties of the soil under *Eucalyptus* and Sal monocultures as compared to the natural Sal lead to the following conclusions :-

1. None of the monocultures (*Eucalyptus* or Sal) could surpass the natural Sal as far as Organic matter accumulation, total N, P and available N, P, K, are concerned.

2. *Eucalyptus* monoculture at 14 years of age has shown higher accumulation of Organic matter in comparison to a fairly old Sal monoculture.

3. The soil under *Eucalyptus* monoculture has a tendency to retain more water in comparison to Sal monoculture.

4. *Eucalyptus* monoculture has resulted in an increase in soil pH, however, Sal monoculture has resulted in lowering of soil pH considering natural Sal as control.

5. Total nitrogen, phosphorus were found to be low under Sal monoculture in comparison to the *Eucalyplus* monoculture. However, the total potassium content was more under Sal monoculture in comparison to *Eucalyptus* monoculture.

6. Available nitrogen and phosphorus were found to be low under Sal monoculture in comparison to *Eucalyptus* monoculture. However, available K was high under Sal monoculture in comparison to *Eucalyptus* monoculture.

7. Raising *Eucalyptus* monoculture in natural Sal area causes no damage to the soil fertility and proves superior to long standing Sal monoculture in the given location

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SUMMARY

The present investigation deals with the impact of growing *Eucalyptus* and Sal monoeultures. On soil of Doon Valley by comparing it with the soil conditions under natural Sal forest. None of the monocultures could surpass the natural Sal as far as Organic matter accumulation, total N, P and available N, P, K are concerned The *Eucalyptus* monoculture of fairly young age has shown higher accumulation of Organic matter in comparison to Sal monculture. The physical and chemical properties of the soil under *Eucalyptus* monoculture has been found to be better in comparison to Sal monoculture It has been concluded that raising *Eucalyptus* monoculture in natural Sal area causes no damage to the soil fertility and proves superior to long standing Sal monculture in Doon Valley.

दून घाटी के प्राकृतिक साल क्षेत्रों की मृदाओं में साल के एकजातिसंवर्धन और युकेलिप्टस लगाने का प्रभाव

लेखक एम०एन० झा व पी० पाण्डे

सारांश

प्रस्तुत अन्वेषण में प्राकृतिक साल वन की मृदा अवस्थाओं के साथ तुलना करके दून घाटी की मृदा पर युकेलिप्टस उगाने और साल के एकजाति संवर्धन के प्रभाव की विवेचना की गई है। जैव पदार्थ एकत्रण, कुल नाइट्रोजन, फास्फोरस तथा उपलब्ध नाइट्रोजन, फास्फोरस और पोटाश की दृष्टि से कोई भी एकल संवर्धन प्राकृतिक साल वन से श्रेष्ठतर नहीं हो सका। काफी कम उम्र का युकेलिप्टस एकजाति वन जैव पदार्थ एकत्रण की दृष्टि से साल एक जाति संवर्धन के मुकाबले में अधिक अच्छा रहा। साल एकजाति वन की मृदा की तुलना में युकेलिप्टस एकजाति वन की मृदा की भौतिक और रासायनिक विशिष्टताएं भी श्रेष्ठतर पाई गई। निष्कर्ष यह पाया गया है कि प्राकृतिक साल वन क्षेत्रों में युकेलिप्टस एकजातिसंवर्धन कराने से मृदा उर्वरता में कोई क्षति नहीं होती तथा दून घाटी में वह दीर्घ काल तक लगे रहने वाले साल वन की अपेक्षा श्रेष्ठतर ही रहती है।

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PINENE RICH ESSENTIAL OIL FROM *EUCALYPTUS TERETICORNIS* LEAVES FROM TARAI AND BHABAR AREAS OF UTTAR PRADESH

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Introduction

In Uttar Pradesh *Eucalyptus tereticornis* plantations exist in large compact blocks in the northern tarai and bhabar areas of Bijnore, Ram Nagar, Haldwani, Pilibhit, Kheri and Bahraich forest divisons. *Eucalyptus* hybrid (mainly *E. tereticornis*) was planted over 81,800 hectares in Uttar Pradesh upto 1978 of which nearly 10,000 hectares are likely to be clear felled every year on a rotation of eight years. During felling operations about 70640 tonnes of fresh green leaves (34450 tonnes of dry leaves) go waste every year. With this leaf potential 600 tonnes of eucalypts oil is obtainable. as on an average 1.75% of essential oil on zero moisture basis is recoverable in Uttar Pradesh (Shiva, 1982). Owing to such a good potential of eucalypts oil annually obtainable from leaves of *Eucalyptus* plantations in U P., analysis of the *E. tereticornis* oils from six forest divisons was made by Gas-liquid chromatography to explore the possibility of their industrial utilization, depending upon their composition.

Materials and Methods

Essential oils distilled from *Eucalyptus tereticornis* leaves from 7, 8, 9 & 10 years old forest plantations of six forest divisions of Uttar Pradesh viz., East Dehra Dun, Bijnore, Haldwani, Pilibhit, South Kheri and Bahraich were analysed by Gas-liquid chromatography for qualitative and quantitative estimation A highly polar capillary stationary phase Dexil-400 was employed for ensuring high separation efficiency on a F-11 Perkin Elmer chromatograph equipped with Flame Ionisation Detector at the Institute of Petroleum Exploration, Dehra Dun on the following conditions.

1.	Model	—Perkin Elmer–F–11 Gas chromatograph
2.	Column	—Dexil-400 G.C. Capillary column 100 m × 0.01 mm
3.	Carrier gas	—Nitrogen
4.	Column temperature	—100°C
5.	Flow rate	—3 ml/minute
6.	Detector type	—Flame-Ionisation Detector
7.	Injection Port temperature	275°C
8.	Chart speed	—5 ml/minute
9.	Attenuation	—Variable

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Table

Component percentages of essential oil samples from E. tereticornis leaves

Names of the Forest Divisions	Age of the Plantations	Alpha-pinene	Beta-pinene	Total alpha & beta-pinenes	Camphene
1	2	3	4	5	6
East Dehra Dun	7	26.14	4.58	30 72	—
	8	11.11	11.93	23.04	—
	9	13.67	11.87	25.54	—
	10	19.78	18.88	38.66	—
Bijnore	7	20.67	22.02	42.69	—
	8	16.75	26.27	42 42	—
	9	21.64	13.60	35.24	—
	10	14.29	23.72	38.01	—
Haldwani	7	26.44	26.69	53.13	—
	8	13.75	22.16	35.91	0 42
	9	29.30	13.56	42.86	—
	10	27.93	17.77	45.70	—
Pilibhit	7	16.92	24.01	40.93	—
	8	22.83	13.28	35.11	—
	9	11.48	18.32	29.80	0.85
	10	24.82	14.38	39.20	Traces
South Kheri	7	17.02	4.08	21.10	1.77
	8	19.37	16.94	36.31	Traces
	9	37.80	25.76	63.56	Traces
	10	20.13	18.01	38.14	—
Bahraich	7	15.11	17.55	32.66	—
	8	10.71	13.10	23.81	—
	9	16.96	31.49	48.45	Traces
	10	16.24	11.04	27.28	—

1

from six forest divisions of U.P. as determined by G.L C.

Delta-3-carene	Alpha-terpinene	Terpinyl-acetate	Para-cymene	Cineole	Beta-Phellandrene
7	8	9	10	11	12
—	20.24	4.16	9.25	30 96	4.62
—	31.89	3.29	17.16	22.19	0.88
—	40.95	2.84	5.31	21.13	2.65
—	23.20	2.15	10.79	25.17	Nil
—	9 50	2.69	16.62	27.46	Nil
—	13.82	6.18	10.63	24.14	1.71
—	12.52	4.63	13.22	26.80	7.21
—	3.70	4.09	14 68	34.55	3.65
—	19.96	2.84	9.08	10.95	Traces
0.42	32.53	2 61	9.16	12.15	5.23
—	1.49	5.74	4.62	43.69	1.59
—	7.72	3.38	11.65	30.56	0.42
—	14.89	2.70	21.12	16.92	1.26
—	1.14	5.57	7.87	46.61	1.05
—	28.10	3.54	10.74	8.48	6.05
Traces	1.46	2.90	44.12	11.75	Traces
—	8.90	9.68	13.08	43.21	0.88
—	7.28	6.31	8.89	27.68	11.87
—	5.40	2.25	7.70	18.48	0.95
—	5.04	3.50	24.04	25.25	2.04
—	Traces	5.04	24.28	36.06	0.60
—	5.37	3.62	11.56	50.72	1.66
—	8.27	5 03	7.40	27.86	1.50
—	8.33	4.33	11 26	40.60	2 11

Identification of peaks of individual constituents was made by coinjection of standard components.

Results and Discussion

The results of Gas-liquid chromatographic examination indicating the percentage of different constituents are recorded in Table 1.

The G.L.C. analysis data given in Table 1 reveals the presence of seven important components viz , alpha-pinene, beta-pinene, alpha-terpinene, beta-phellandrene, para-cymene, terpinyl-acetate and cineole from plantations of different age extending over different eco-climatic zones in Uttar Pradesh.

The percentage range of occurrence of each component is indicated below :

Range af component percentages determined by G.L C. in E. tereticornis oil :

(i)	Alpha-pinene	—	11.11	to	37.80	per cent
(ii)	Beta-pinene	—	11.87	to	31.49	,,
	Total of alpha & beta-pinenes	—	21.10	to	63.56	,,
(iii)	Alpha-terpinene	—	1.14	to	40.95	,,
(iv)	Beta phellandrene	—	0.60	to	11.87	,,
(v)	Para-cymene	—	7.40	to	44.12	,,
(vi)	Terpinyl-acetate	—	2.15	to	9.68	,,
(vii)	Cineole	—	10.95	to	50.72	,,

Gas-liquid chromatographic examination reveals that *E. tereticornis* oil appears to be different from oils of *E. globlus* and *E. citriodora*. Both of these oils have been recognised as medicinal and perfumery oils respectively, while *E. tereticornis* oil may serve as an additional source of alpha and Beta-pinenes in India which are basic raw materials for manufacture of aromatic chemicals for industrial utilization. Thus *E. tereticornis* oil is likely to prove a good source of pinenes like turpentine from pine resin if produced economically. In addition it may also be a source of alpha-terpinene, para-cymene and terpinyl-acetate which may be used as an independent raw material for other terpene based industries. The results also indicate that range of cineole content obtainable from *E. tereticornis* in Uttar Pradesh is not worth commercial exploitation as eucalypts oil should contain 60-72% cineole according to the specifications of the Indian standard Institution (I.S.I., 1957). This requirement is met with in *Eucalyptus globulus* oil which is commercially exploited for its cineole. *E. tereticornis* oil may, therefore, be considered to be an alternative promising source of pinenes.

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SUMMARY

The results of analysis of the essential oil samples from *Eucalyptus tereticornis* leaves collected from six forest divisions of tarai and bhabar areas in U.P. as determined by Gas-liquid chromatography have been presented in this paper. The data on component percentages given in this paper reveal that *E. tereticornis* oil is generally rich in pinenes which may prove to be a good source of pinenes for industrial utilization in the manufacture of aromatic chemicals etc.

उत्तर प्रदेश के तराई-भाबर क्षेत्र में लगे युकेलिप्टस टेरेटिकार्निस की पत्तियों से पाइनीन संपन्न उत्पत तेल

लेखक एम०पी० शिवा, जी०एस० पालीवाल, कुलदीप चन्द्र व मंजु माथुर

सारांश

प्रस्तुत अभिपत्र में उत्तर प्रदेश के तराई-भाबर क्षेत्र के छह वन मण्डलों से एकत्रित की गई युकेलिप्टस टेरेटिकार्निस की पत्तियों से निकाले गये उत्पत (सुगंध) तेल नमूनों का गैस-लिक्विड वर्णचित्रांकन (क्रोमेटोग्राफी) रीति से किये गये विश्लेषण के परिणाम किये गये हें। इस अभिपत्र में संयोगांगों के प्रतिशत आंकड़ों से पता चलता है कि यु० टेरेटिकार्निस का तेल पाइनीन में धनी है जो सुरमित रसायन पदार्थों आदि के निर्माण में औद्योगिक उपयोजन के लिए पाइनीनों का अच्छा स्रोत सिद्ध हो सकता है।

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PROVENANCE TRIALS OF *EUCALYPTUS*

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Introduction

Euculyptus are endemic to Australia. In Australia, this species is found right from dry tropical zone to wet temperate zone. There are about 700 known species and 138 recognised *Eucalyptus* varieties. This is a species, which grows on all kinds of soils. *Eucalyptus* are the most widely planted commercial trees in India. They are mainly used for paper and rayon pulp, besides firewood and for poles. It yields fairly good charcoal. *Eucalyptus citriodora* and *Eucalyptus globulus* are oil yielding species that are planted in India It is also inferred that the yield of honey has increased in the neighbour hood of *Eucatyptus* plantations.

In India, the raising of *Eucalyptus* has caught up very well with the private farmers also. It is raised both under rainfed and irrigated conditions.

At present the Mysore gum (*Eucalyptus hybrid/tereticornis*) is grown on large scale.

However, it has been noticed that this *Eucalyptus hybrid* is not faring well out side the Mysore plateau, when grown under dry conditions.

Since a fast growing species was an essential requirement to meet the paper and pulp industry, small size timber, and fuel due to the depletion of natural forest. The species which gave encouraging results was *Eucalyptus*. This is a very fast growlng species which can, grow in almost all climatic and edaphic conditions.

It was found essential that out of the 700 species available in Australia, the species which can be raised successfully in India should be tried on an experimental basis. Keeping this in view, seeds of various provenances of different species of *Eucalyptus* were imported from Australia and experimental trials were conducted in Kerala, Andhra Pradesh, Bihar, Orissa, Maharashtra, Madhya Pradesh and Haryana.

Provenance trials of *Eucalyptus* species

The CSIRO, Australia has been kind enough to send seeds of various provenances of different species of *Eucalyptus* from the year 1979. The seeds received are distributed to the Forest Departments and the Forest Corporations through out the country.

Even though while sending the seed, requests have been made to send the growth statistics, the response has been very unsatisfactory. For want of growth statistics, seeds of provenances of various species have been curtailed to about 3 to 4 species mainly *Eucalyptus camaldulensis*, *Eucalyptus tereticornis* and *Eucalyptus citriodora*.

Growth statistics have been received from only 3 states viz. Andhra Pradesh Forest Development Corporation of Andhra Pradesh State and Research Branch of Maharashtra State and Bihar State. Statistics from our own Sub-Centre in Haryana State are also available for computation. It is generally seen that *Eucalyptus camaldulensis* provenances are doing better in dry zones. The provenances which are shaping well are as follows :

1. Petford
2. Katherine
3. Bullock creek
4. Murchison river
5. Isdell river
6. Lennard river
7. Goodairs creek
8. Agnew
9. Irvine bank
10. West Dimbulah

The latest growth statistics have been computed and shown in Statement No. 1

Statement – 1

Growth Statistics of Eucalyptus camaldulensis

Provenances	Height (m)	Girth (cms)	Date of observation
Petford	RA 13.50	41	30-6-1983
	HA 10.0	20.25	27-3-1982
	RN 8.0	—	22-1-1982
	N 4.63	11.00	10-4-1982
Katherine	RA 13.75	44.00	30-6-1983
	HA 9.50	27.25	27-1-1982
	RN 7.00	—	22-1-1982
	N 4.68	16.00	10-4-1982
Bullock creek	RA 13.00	34.05	30-6-1983
	HA 9.60	29.05	27-3-1982
	RN 7.10	—	22-1-1982
	N 4.22	10.00	10-4-1982
Murchison river	RA 13.00	32.05	30-6-1983
	HA 10.10	29.50	27-3-1982
	RN 6.60	—	22-1-1982
	N 4.59	13.00	10-4-1982

RA — Rajahmundry (Andhra Pradesh)
HA — Haryana Sub-centre
RN — Ranchi (Bihar State)
N — Nagpur (Maharashtra)

Eucalyptus tereticornis is doing very well in areas where the rainfall is between 63 cm and 103 cm. As per the growth statistics received, and after computation, the following provenances appear to be doing well :

1. S. Laura
2. Mt. Molley
3. Cook town
4. Mt. Poverty
5. North-West Mareeba

The latest growth statistics have been computed and shown in Statement No. 2.

Statement—2

Growth Statistics of Eucalyptus tereticornis

Provenance	Hight (m)	Girth (gms)	Date of observation
Cook town	HA 14.05	39.00	27-3-1982
	RA 13 50	36.00	30-6-1983
	RN 7.50	-	22-1-1982
	N 2.73	7	10-4-1982
Mt. Molloy	RA 13.80	38 05	30-6-1983
	HA 11.00	43.00	27-3-1982
	RN 7.00	—	22-1-1982
	N 3.31	9	10-4-1982
S. Laura	HA 13.50	38.00	30-6-1983
	HA 12.05	28.00	27-3-1982
	RN 8.20	—	22-1-1982
	N 2.52	10	10-4-1982
North-West Mareeba	RA 13.00	38.05	30-6-1983
	HA 12.00	34.00	27-3-1983
	RN 6.30	—	22-1-1982
	N 2.20	3	10-4-1982

RA—Rajahmundry (Andhra Pradesh State)
HA—Haryana Sub-Centre
RN—Ranchi (Bihar State)
N—Nagpur (Maharashtra State).

Andhra Pradesh
(Rajahmundry)

Year of Plantation 1979
Last date of recording 30-6-1983.

	Mtrs.	Girth (cms)
E. camaldulensis		
1. Katherine	13 75	44.00
2. Irvine bank	13.50	41.00
3. Petford	13.50	39.5
4. Isdell river	13.25	36.5
5. West Dimbulah	13.00	41.00
6 Guidir river moree	13.00	36.00
7. Fortescue river	13.00	36.00
8. New castle waters	13.00	35 05
9. Bullock creek	13.00	34.05
10. Emmet	13.00	33 05
11. Murchison river	13.00	32.05
12. Goodairs creek	12.05	35.00
13. Lennard river	12.50	36.00
E tereticornis		
1. Mt. Molloy	13.80	38.05
2. S. Laura	13.50	38.00
3. Cook town	13.50	36.00
4. North-West Mareeba	13.00	38.05
5. Mt. Poverty	13.00	36.05

Bihar State
(Ranchi)

Year of Plantation 23th July 1979
Last date of observation 22-1-82

	Mts.
E camaldulensis	
1. Petford	8.00
2. Agnew	7.60
3. Lennard river	7.30
4. Isdell river	7.20
5. Bullock creek	7.10
6. Katherine	7.00
7. Goodairs creek	6.80
8. Gilgandra	6.70
9. Murchison river	6.60
10. Irvine bank	6.50
11. Ayers rock	6.40
12. West Dimbulah	6.00
E. tereticornis	
1. S. Laura	8.20
2. Cook town	7.50
3. Mt. Poverty	7.50
4. Mt. Molloy	7.00
5. Mareeba	6.30

Haryana Sub-Centre

Year of Plantation 28-2-80
Last date of observation 27-3-82

	Mts.	Girth (cms)
E camaldulensis		
1. Murchison river	10.10	29.50
2. Petford	10.00	20.25
3. Lenrard river	9.90	25.20
4. Isdell river	9.90	21.25
5. Agnew	9.75	27.05
6. Bullock creek	9.60	29.05
7. Katherine	9.50	27.25
8. Barwan river	9.25	29.05
9. Ayers rock	9.25	22.00
10. Irvine bank	9.00	22.75
11. Halls creek	8.60	24.08
12. Ewenmore creek	8.44	21.25
E tereticornis		
1. Cook town	14 05	39.00
2. S. Laura	12.05	28.00
3. North-West Mareeba	12 00	34.00
4. Mt. Molly	11.00	43.00
5. Mt. Poverty	10.05	35 00

Maharashtra State

(Nagpur)

Year of Plantation 14-8-79
Last date of observation 29-3-82
10-4-82

	Mts	Girth (cms)
E. camaldulensis		
1. Goodairs creek	5.23	15
2. Halls creek	4.96	11
3. Katherine	4.68	16
4. Lennard river	4.65	12
5. Petford	4.63	11
6. Murchison river	4.59	13
7. West Dimbulah	4.48	10
8. Isdell river	4.28	15
9. Agnew	4.22	13
10. Bullock creek	4.22	10
11. Irvine bank	3.86	9
12. Barwan river	3.72	9
E. tereticornis		
1. South Loura	3.52	10
2. Mt Molloy	3.31	9
3. Cook town	2.73	7
4. Mt. Poverty	2.73	6
5. North-West Mareeba	2.20	3

TRANSPIRATION AS AFFECTED BY SOIL MOISTURE IN *EUCALYPTUS TERETICORNIS* SEEDLINGS

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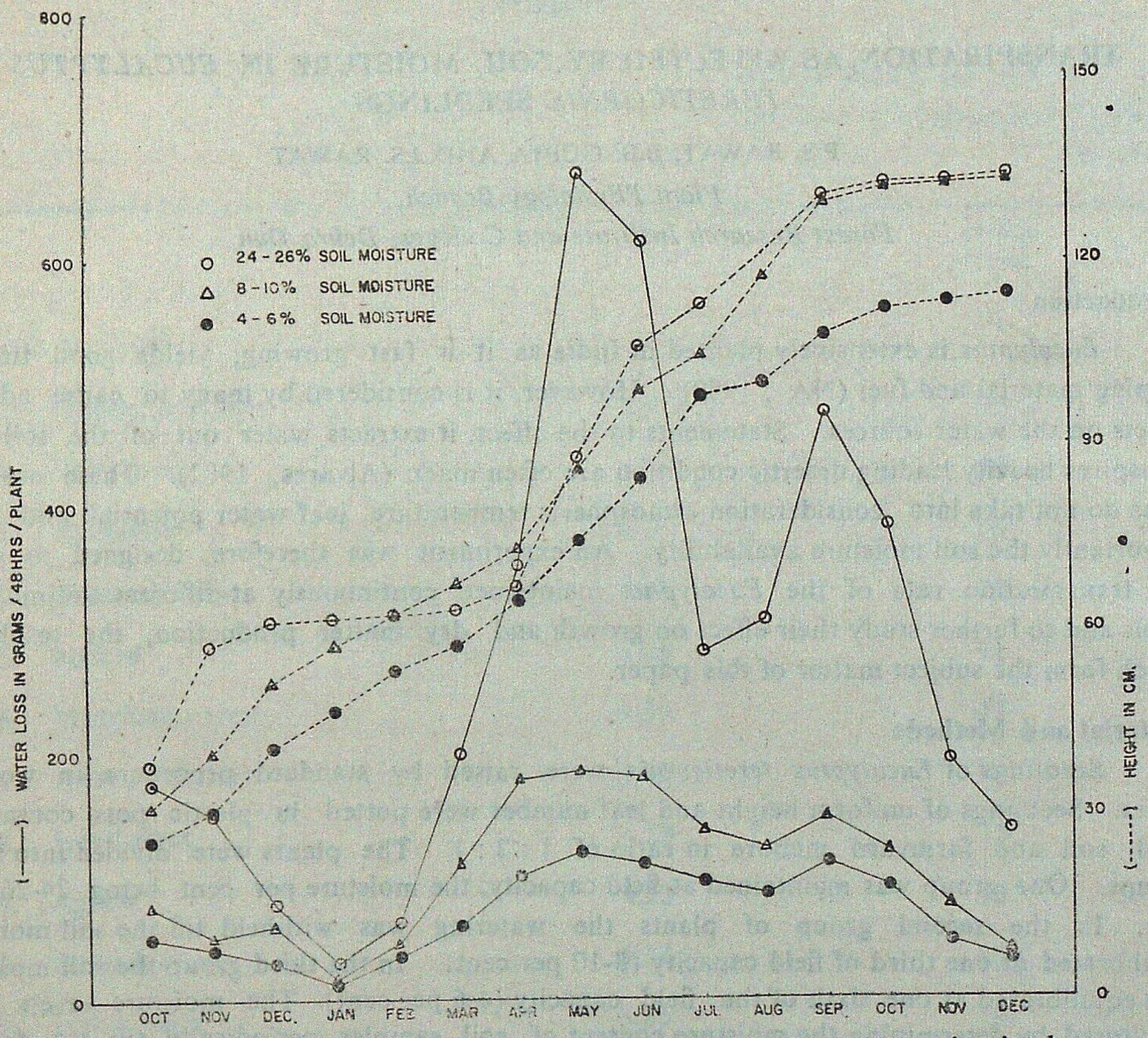
Introduction

Eucalyptus is extensively planted in India as it is fast growing, yields good timber, pulping material and fuel (NA , 1980) However, it is considered by many to cause adverse effects on the water sources. Statements to the affect, it extracts water out of the soil and transpires heavily leading desertic condition are often made (Alvares, 1982). These observations do not take into consideration atmospheric temperature, leaf water potential and more importantly the soil moisture availability. An experiment was therefore, designed to study the transpiration rate of the *Eucalyptus* maintained continuously at different soil moisture levels and to further study their effect on growth and dry matter production, the results of which form the subject matter of this paper.

Material and Methods

Seedlings of *Eucalyptus tereticornis* were raised by standard procedure in wooden boxes. Seedlings of uniform height and leaf number were potted in plastic pots containing sand, soil and farmyard manure in ratio of 1 : 2 : 1. The plants were divided into three groups. One group was maintained at field capacity, the moisture per cent being 24-26 per cent. In the second group of plants the watering was withheld till the soil moisture equilibrated at one third of field capacity (8-10 per cent). In the third group the soil moisture was equilibrated at one sixth of the field capacity (4-6 per cent). The moisture levels were monitored by determining the moisture content of soil samples periodically till the desired soil moisture level was attained. After attainment of desired soil moisture level the experimental pots were covered with incised polythene sheets which was further tied around the plastic pots. The incised polythene sheets being made air tight with adhesive tape. This was done to prevent the loss of moisture by surface evoporation from soil. The soil moisture in each pot was kept constant by continuously weighing and replenishing the lost water with the help of a wash bottle nozzle through a pore pierced in polythene. The pore was repeatedly closed after watering. In this method the loss of water was entirely accounted for due to transpiration. There were ten uniform replications for each of the three soil moisture levels. The weighing and replenishment of lost water was done regularly at 48 hours interval for a period of fifteen months. The height was measured at monthly intervals. On completion of the experiments, the seedling were carefully uprooted washed throughly and fresh and dry weight recorded. The mean water transpired per 48 hours per plant for different months is presented in Fig. 1 alongwith the mean height of the plants in different months.

Fig. 1



Transpiration rates and height of plants in different months maintained at different soil moisture level.

Results and Discussion

The trend of increase in height during fifteen months the period of experimentation in all the treatments was similar. However, the height was generally more in plants maintained at soil moisture of 24-26 per cent except in the month of March and April. The lower height was always recorded in plants maintained at soil moisture of 4-6 per cent. Onwards of twelveth month the plants maintained at 24-26 per cent soil moisture and 8-10 per cent soil moisture showed almost the same height. The plants maintained at 4-6 per cent soil moisture showed lower height growth throughout the period of experimentation, the height decrement was not proportionate to decrement in soil moisture levels. With regard to the amount of water transpired by the plant, it is clear that plants maintained at all the soil moisture regimes showed essentially similar trend with two peaks, one in the month of May and other in the month of September with a dip in the month of July and August. However, the plants

maintained at 24–26 per cent soil moisture showed sharp peaks due to steep increase in water transpired during the month of April and May the air temperature increases sharply whereas during the month of July and August the air humidity increases sharply in the experimental zone (due to high precipitation) which explains the peaks and dips in the amount of water transpired during these periods. The sharper increase in the amount of water transpired by the plants maintained at field capacity (24–26 per cent) is because of abundant availability of soil moisture coupled with adequate turgor pressure in the leaf cells Under conditions of field capacity therefore transpiration is a function of atmospheric aridity rather than being controlled by stomatal mechanisms. The rate of increase of water loss by plants maintained at 8-10 and 4–9 per cent soil moisture was not as steep during the month of March, April and May. This may probably due to the fact that under the conditions of water stress the leaf water potential gets lowered resulting in stomatal closure, as it is well known that stomatal behaviour is conditioned by turgor relations of the plant and is comparatively uneffected by relative humidity of the ambient air (Meidner and Mansfield, 1968).

The data presented on dry matter yield of shoot and root alongwith moisture content in plants maintained at different soil moisture level at the termination of the experiment is presented in Table 1. It is interesting to note that per cent moisture level in roots and shoots in all the treatments was nearly the same. The maximum dry matter was found in plants maintained at 24–26 per cent soil moisture and the minimum in plants of 4–6 per cent soil moisture. Nevertheless, the ultimate dry matter production was not affected in proportion to the soil moisture availability as is evident from the fact that plants maintained at 8-10 per cent soil moisture produced nearly 75 per cent of the dry matter as that of the plants maintained at 24–26 per cent soil moisture; likewise plants maintained at 4–6 per cent soil moisture (one sixth the level of 24–26 per cent soil moisture) produced 62 per cent of dry matter as that of plant maintained at 24–26 per cent soil moisture. In other words though the soil moisture is reduced by 66 and 84 per cent the corresponding reduction in dry matter was only around 25 and 38 per cent, respectively.

Table 1

Fresh weight, dry weight and per cent moisture in shoot and root of plants maintained at different soil moisture level

Soil Moisture level (%)	Shoot*			Root*		
	Fresh weight	Dry weight	Moisture (%)	Fresh weight	Dry weight	Moisture (%)
24–26	110 6	54.4	50.8	126.7	58.7	53.7
8–10	101.4	47.7	53.0	87.4	37.8	56.7
4–6	79.8	38.3	52.0	60.1	31.7	47 2

*Average of 10 replications.

The results presented, thus, clearly show that when the soil moisture is limiting the plants tend to restrict the water loss so that growth is not seriously affected. Thus the water conserving mechanisms possibly triggered only under conditions of moisture stress. When the moisture is abundantly available as in case of the plants which are maintained at field capacity the water is allowed to be transpired heavily as the turgor pressure of the leaf cells is not limiting. This is normally termed as "Luxury consumption" of water by plants which is not only specific to *Eucalyptus* but has also been reported in *Dalbergia sissoo* (Siddiqui, 1967). Dabral (1970) has shown that water utilised by *E. citriodora* was 5526 mm per seedling per year whereas it was 1200 mm per seedlings per year for *E camaldulensis* (Raeder-Roitzsch and Masrur, 1968). The age of seedlings was around 6 to 16 months in both the cases. The seedling in former, however were regularly watered to field capacity. Saltiel (1965) has successfully utilised the "Luxury consumption"of behaviour of *Eucalyptus* to drain certain swamps in Israel. The results reported here clearly show that the high rate of transpiration by *Eucalyptus* is an adpatability operative under the conditions of adequate soil moisture. The contradicting observations that are found in literature often overlooks the soil moisture regime at which the seedlings were grown. Statements on transpiratory behaviour should perforce be made in conjuction with the available soil moisture in the soil failing which the conclusions may be misleading.

Acknowledgement

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SUMMARY

An experiment was designed to study the transpiration rate of *Eucalyptus tereticornis* maintained in different soil moisture levels. It was found that transpiration in this species is a function of atmospheric aridity under condition of abundant soil moisture whereas under condition of restricted soil moisture water conserving mechanisms are in operation. Thus, the dry matter production is not seriously affected even under conditions of low soil moisture levels.

युकेलिप्टस टेरेटिकार्निस के पौधों में मृदा नमी से प्रभावित वाष्पोत्सर्जन

लेखक पी०एस० रावत, बी०बी० गुप्त व जे०एस० रावत

सारांश

यह संपरीक्षण विभिन्न मृदा नमी स्तरों पर रखे गये युकेलिप्टस टेरेटिकार्निस के पौधों की वाष्पोत्सर्जन दर का अध्ययन करने के लिए बनाया गया था। देखने में यह आया कि इस जाति में वाष्पोत्सर्जन प्रचुर मृदा नमी रहने पर वातावरण की निर्जलता से होता है जब कि मृदा नमी सीमित रह जाने पर उसके जल संरक्षण यन्त्र कार्य करने लग जाते हैं। इस प्रकार मृदा नमी का स्तर निम्न हो जाने पर भी इस जाति के शुष्क पदार्थ उत्पादन में कोई गम्भीर कुप्रभाव नहीं पड़ता।

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EUCALYPTUS IN KERALA STATE

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Introduction

About 25% of the man-made forest in Kerala State accounts for *Eucalyptus*. *Eucalyptus grandis* is the species planted in the High Ranges whereas in the plains *Eucalyptus tereticornis* has been the choice. While *Eucalyptus grandis* could be raised successfully in the grasslands of plateaus of the Western ghat, *Eucalyptus tereticornis* planted in the plains converting lush green natural vegetation present a sad picture in that it is subjected to pests and diseases lowering the yield to about one-third of *Eucalyptus grandis*. Survival of the three pulpwood industries in the State depends mainly on *Eucalyptus* as an alternative is to be yet found out.

Plantations

Planting of *Eucalyptus grandis* commenced in the year 1958 in the grasslands of High Ranges with an altitude of 1000 metres or so. A Special Division was formed to implement this programme of afforestation of grasslands under the Five Year Plan Scheme. Almost all the suitable grasslands in the State round about this elevation have been brought under *Eucalyptus grandis* and comprises an extent of about 14000 hectares. *Eucalyptus tereticornis* has been subsequently introduced with a view to produce pulpwood on a large scale by replacing the existing natural forests. A Special Circle designated Industrial Plantation Circle with four Divisions was formed to implement this scheme. Later on in the year 1976, the Kerala Forest Development Corporation was formed with a target of about 40000 ha to be converted into *Eucalyptus* at the rate of 5000 ha annually. The Corporation could so far plant only 7000 ha. Recently, a perspective plan has been prepared which took stock of the raw material position in the State vis-a-vis our commitment to the industries and the trend is not in favour of carrying *Eucalyptus* to the natural forest belt any further.

Yield

The average yield of *Eucalyptus grandis* at the rotation age of 8 years is about 80 m t. per hectare There are well looked after plantations which yield upto 150 m.t. or more and those uncared for producing as low as 30 m.t. or even less. The *Eucalyptus tereticornis* plantations on an average yield only about 35 m.t. per hectare, the range of production being anything between 10 to 80 m.t.

Year-wise area Planted with Eucalyptus

Area in hectares

Year	Forest Department		K. F. D. C.		Total		Remarks
	Eucalyptus grandis	*Eucalyptus tereticornis*	*Eucalyptus grandis*	*Eucalyptus tereticornis*	*Eucalyptus grandis*	*Eucalyptus tereticornis*	
1958	45.021	45.021	—	—	45.021	—	
1959	139.895	—	—	—	139.895	—	
1960	86.198	—	—	—	86.198	—	
1961	481.869	—	—	—	481.869	—	
1962	955.218	165.893	—	—	955.218	165.893	
1963	1481.480	202.392	—	—	1481.480	202 392	
1964	1644.276	398.324	—	—	1644.276	398 324	
1965	1958.470	484 251	—	—	1958.470	484.251	
1966	1318.786	1120.163	—	—	1318.786	1120.163	
1967	1724.735	2377 602	—	—	1724.735	2377.602	
1968	274.150	2119.385	—	—	274.150	2119.385	
1969	—	2296 753	—	—	—	2296.753	
1970	94.000	1089.232	—	—	94.000	1089.232	
1971	153.239	224.700	—	—	153.239	224.700	
1972	46.000	271.050	—	—	46.000	271.050	
1973	132.000	621.973	—	—	132.000	621.973	
1974	39.750	456.820	—	—	39.750	456 820	
1975	174.760	466.210	—	—	174.760	466.210	
1976	113.730	262.810	—	534.000	113.730	796 810	
1977	39.254	293.640	200.000	1312.000	239·254	1605 640	
1978	—	357.430	300 000	866.000	300.000	1223.430	
1979	—	5124.880	749.000	1050.000	749.000	6174 880	
1980	385.800	738.900	1089.000	137.000	1474 800	875.900	
1981	573.700	469.700	583.000	159.000	1156.700	628 700	
Total	11862.331	19542.108	2921.000	4058.000	14783.331	23600.108	

Growing stock

The total growing stock of *Eucalyptus* is assessed to be about 22 lakhs m.t. There is much scope for improving the growing stock by intensive cultural practices at least at the coppicing stage Though this is an aspect on which there are differing views among Kerala Foresters, it is worth mentioning that certain plantations in the Wynad planteau have been successfully augmented during the post-coppicing operations.

Dependent Industries

There are three pulpwood industries in the State viz : (i) Kerala News Print Project, (ii) Punalur Paper Mills and (iii) Gwalior Rayons. The three industries together annually need 3,30,000 m.t. of *Eucalyptus* wood and unless the growing stock is improved by effective augmentation operations, the gap between requirement and supply may not only close but is likely to widen further.

Fire

Much destruction has been caused to the plantations especially to the *Eucalyptus grandis* raised in the grasslands. Fire risk is there during summer months (January to April) due to the existence of grasslands around the plantations and the presence of grass (mainly elephant grass, *Typha elephantum*) underneath which dries up and become flammable. If the fire is not detected and put off in the beginning itself, it will develop into a devastating crown fire hastened by strong wind devouring extensive areas of plantations in no time. A fire plan has been prepared by Mr. Rasmussen, former Forest Fire Advisor at Kulamavu Fire Training Centre of Kerala (established under the Indo-New Zealand Technical Co-operation Scheme) for the Grassland Afforestation Division, Pamba cultivating about 8000 hectares of *Eucalyptus grandis*, considerable extent of which has been burnt. The fire plan is awaiting approval and implementation.

Taungya

Almost all the *Eucalyptus tereticornis* plantations have been raised (after clearance of the natural forests) under taungya system. The agricultural crop has been mainly tapioca which grows luxuriantly in the virgin soil closing up its canopy hiding the young *Eucalyptus tereticornis* plant causing untold misery by shutting off the light and creating a green house condition for the development of pathogens Tapioca cultivation not only depletes the soil, but displaces it also due to increased run off and results in a site devoid of any top soil essential for the growth and development of any plant species. The poor yield of *Eucalyptus tereticornis* plantations in the State is largely attributable to this taungya evil.

Pathogens

Seedling blight caused by *Cylindrocladium quinqueseptatum* is one of the major limiting factors in raising this crop. The stem pathogen *Corticim salmonicolour* causes pink disease. The tapioca crop mentioned in the previous para exacerbates the fungal diseases. The fungal diseases become so serious that a Eucalyptus Fungus Investigation Unit was established

few years back by the Kerala News Print Project with the active participation of the Forest Department. The unit has done extensive disease surveys in relation to disease incidence and productivity in different areas of Kerala and through their laboratory studies, they have identified an effective fungicide formulation to control both pink disease and *Cylindrocladium* blight. Further, economically viable large scale application technology is being worked out. They have already made certain recommendations to minimise the disease severity due to taungya practice.

Termite

Among Forest species, *Eucalyptus* seedling is one of the most susceptable to termites which feed on the roots. The attack is severe both in the nursery as well as in the plantation stage up to an age of 2-3 years. Effective control of termites could be achieved by long persistent synthetic pesticides like aldrin, aldrex etc. The investigations conducted by the Kerala Forest Research Institute on the possibility of non-insecticidal control of termites have not yielded any useful result.

Soil properties

There is a general feeling that the fast growing short rotation *Eucalyptus* make heavy demands on the soil and that the monoculture of such trees leads to soil deterioration. A study has been undertaken by the Kerala Forest Research Institute (K.F.R.I. Research Report–8) to evaluate the change in soil properties under current *Eucalyptus* plantations. The study indicates generally high fertility of the soils, in uncoppiced as well as in the first coppiced plantations, based on relatively higher levels of organic carbon and cation exchange capacity, two integrative properties of soils. However, this requires a more comprehensive and continuous study particularly in areas subjected to taungya (Tapioca) before arriving at a specific conclusion. Remedial measures to prevent nutrient depletion usually associated with a fast growing short rotation crop like *Eucalyptus* and aggravated by taungya practice have to be evolved.

Underground water

The fast growth of *Eucalyptus* no doubt indicates relatively higher consumption of soil moisture. The steady growth during the year round makes equal demand for moisture in summer as in the rainy months. Naturally many believe that planting of *Eucalyptus* results in more and more drier conditions due to its higher consumption of ground water. Several organisations sprung up recently in the name of ecology and environment are arch-critics of *Eucalyptus* in that they make use of every opportunity to preach that it lowers the water table and dries up even streams which were perennial. This is an important environmental aspect requiring urgent detailed study to arrive at the truth.

Secondary succession

As already pointed out, major part of *Eucalyptus grandis* in the State has been raised in the grasslands of high ranges. In areas where protection from fire has been effective, not only colonisation of evergreen shrubs have commenced but tree species (evergreen) have also established suggesting a quick succession towards a climax vegetation. It is a feast to the eye and a challenge to the inquisitor to see and study the thick evergreen vegetation holding the tall thin *Eucalyptus* trees as if to ward off an evil eye. A research plot has already been laid out to study this welcome phenomenon and hope this will provide ample data to the research scholars really interested in this field.

UTILISATION OF *EUCALYPTUS* HYBRID—A REVIEW

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Introduction

Eucalyptus tereticornis popularly known as *Eucalyptus* hybrid or Mysore gum has been planted extensively throughout India under the plantation programmes in the successive five year plans. Although most of the plantations have been raised for pulp and paper for which the species is well known to provide an excellent raw material (Shukla, 1980) the questions are often posed about its suitability for other purposes. In order to determine its suitability for varied purposes, several investigations were undertaken in the recent past and some are underway at Forest Research Institute, Dehra Dun. The results of these studies are briefly reviewed in the present paper.

Physical and Mechanical properties

For determination of physical and mechanical properties, *Eucalyptus* hybrid has been tested from few localities. The results of the important properties (Sekhar *et al.* 1968; Sekhar and Rajput, 1978; Shukla *et al.* 1981; Shukla and Rajput, 1983 and Jain, 1969) are given below along with the localities from where the material for testing was received :

Localities from where *Eucalyptus* hybrid was obtained	Properties		
	Standard sp gravity	Green conditions	
		Modulus of rupture (kg/cm²)	Max. crushing stress (kg/cm²)
Panchmahal (Gujarat)	0.563	960	288
Mahakanam (Tamil Nadu)	0.596	510	291
Devanhally (Karnataka)	0 713	898	402
Ootacamund (Tamil Nadu)	0.571	871	356

In addition to this a large number of samples of *Eucalyptus* hybrid of varying age from different states have been tested for specific gravity alone. These included different localities of Tamil Nadu, Karnataka, Uttar Pradesh, Gujarat and Madhya Pradesh. Standard specific gravity of eight to nine years old plantations which is regarded as standard rotation period for the species have been found to vary from 0.521 to 0.744 (Shukla and Rajput, 1981).

The comparative suitability indices of *Eucalyptus* hybrid (with teak as 100) have also been worked out from eight year old material obtained from Mahakanam division of Tamil Nadu (Sekhar *et al.* 1968) and are given as follows :

Weight	...	110
Strength as a beam	...	75
Stiffness as a beam	...	70
Suitability as a post	...	65
Shock resisting ability	...	115
Shear	...	90
Surface hardness	...	115

From the above, it is clear that *Eucalyptus* hybrid is 10% heavier, 15% ha der and 15% higher in shock resisting ability in comparison to teak. However, it is 25% weaker than teak in strength. According to classification of timbers for structural use as per IS : 883-1970 "Code of practice for design of structural timber in building" the species falls in Group B alongwith species like Kokko, benteak, bijasal and laurel.

Seasoning, preservation and working properties

Eucalyptus hybrid has been found to be a highly refractorv timber developing severe collapse, surface cracks, warping and twisting during the process of air or kiln seasoning. Even the pre-treatment with urea eliminates only surface and end cracking and not the collapse and warping which are the major defects noticed in tangentially sawn planks (Purkayastha, 1982). It has been observed that this defect is almost completely eliminated when the logs are converted into planks by radial sawing. The planks so obtained seasons well without such defects (Pandey, *et al.*). Thus changing the pattern of conversion *Eucalyptus* hybrid can be seasoned with less degrade.

The species belongs to non-durable and non-treatable class (Sud and Sharma, 1976), which is the greatest drawback for its diversified utilisation.

Under machining operations it has been found that *Eucalyptus* hybrid can be very well machine planed, turned, bored and mortised. The working quality index of the species is found to be 94 as compared to teak as 100 (Rajput *et al.* 1983).

The finish adaptability of the species is 104 as compared to teak as 100 (Jaitly *et al* 1983).

Plywood and Composite Wood

Particle boards, hardboards and plywood have also been developed from *Eucalyptus* hybrid (Singh *et al.* 1974). Hardboards of satisfactory properties conforming to IS : 1658-1977 "Specification for fibre hardboards" have been developed from *E.* hybrid by semi-chemical pulp process by adding 1% sizing material to the pulp obtained from 2% and 3% alkali concentration (Chauhan and Bist, 1983). Thus in the presence of sizing agent, satisfactory hardboards can be prepared from *Eucalyptus* hybrid by semi-chemical pulping process. Experiments on the development of plywood from *Eucalyptus* hybrid have not so far shown satisfactory results (Gupta and Chauhan, 1978). It has been observed that the species does not give satisfactory bond with UF and PF resins in the ordinary course and offers gluing difficulties. But by modifying the resin with suitable wetting agents and plasticisers. It is possible to obtain satisfactory bond. Further experiments to develop suitable plywood from this species are in progress. Some studies on the effect of extractive removal on wettability and glue bond quality have already been completed (Negi and Rawat). The results obtained so far indicate that extractive removal by acetone as well as hot water increases wettability and consequently the glue shear strength considerably.

Chemical utilisation

There is a vast potential of chemical utilisation of *Eucalyptus* hybrid (Theagrajan and Prabhu, 1981). Some trees of *E.* hybrid yield Cineolerich medicinal oil which is similar in quality to that obtained from *E. globulus*. A method to screen such trees has already been developed so as to select Cineolerich trees (Theagrajan and Rao, 1970). The bark of *Eucalyptus* hybrid can be used for producing oxalic acid. Experiments have showd that 40–45% oxalic acid can be obtained using nitric acid (Prabhu and Theagrajan, 1977), as oxidising agent.

Wood poles, tool handles and furniture

Eucalyptus hybrid has been tested from several localities of Uttar Pradesh and Punjab for its use as poles for overhead power and telecommunication lines and construction. The species has been found to be suitable for use as poles for overhead power and telecommunication lines from strength point of view. The species falls in Group C as par IS : 876–1970 "Specification for overhead pawer and telecommunication lines" (Rajput *et al.* 1980). But as the species belongs to non-durable and non-treatable class, only poles having a sapwood ring of at least 31 mm thick can be used for the purpose and care should be taken that the penetration of preservative is complete in the entire sapwood portion as per the general recommendation made in IS : 401–1982 "Code of pracitce for preservation of timber". On the basis of the strength values of *Eucalyptus* hybrid in round form, it is suitable for scaffolding purposes in building industry as well as for ballies for erection of temporary structures and fence posts (Rajput *et. al.* 1980).

In view of large scale plantations of *Eucalyptus* species in villages, its suitability for tool handles and other agricultural implements have also been determined. Tool handle figure calculated on the basis of mechanical strength of *Eucalyptus* hybrid of 8 years age from

Mahakanam Division of Tamil Nadu has been found to be 94 (as against 100 for teak). If total variation of strength of *E.* hybrid tested so far is taken into account, the tool handle figure varies from 85 to 119. Thus according to classification of species suitable for tool handles as per IS : 620-1975 "Indian Standard specification for general requirements for wooden tool handles", the species falls in class II and even the worst lot is not likely to fall below class III. In order to see the performance of the species in actual use, handles for hand axe, felling axe, shovels, hand hammers, tent mallets and plumbers mellets were prepared as per concerned Indian Standards and dipped in linseed oil at room temperature for 24 hours and then stored. Inspection after 6 months showed no development of defect and in actual use later, the handles gave satisfactory service (Rajput and Gulati).

Some very good simple as well as bent wood furnitures items have been developed from *Eucalyptus* hybrid and polished to good finish and gloss after suitable seasoning. The furniture items are defect free and are in service for more than one year (Jaitly *et al.* 1983) Results of preliminary experiments carried out recently indicate that this species has also a potential for use for carving

Thus there are enormus avenues for use of *Eucalyptus* hybrid grown extensively throughout India in addition to pulp and paper which is of cousre the main industrial use for which these plantations are mostly grown.

SUMMARY

Eucalyptus tereticornis popularly known as _Eucalyptus_ hybrid or Mysore gum has been planted extensively throughout India under the plantation programmes in the successive five year plans. Although most of the plantations have been raised for pulp an] paper for which the species provides an excellent raw material, the questions are often posed about its suitability for other purposes. In order to determine its suitability for varied purposes, investigations have been recently undertaken and several are underway at Forest Research Institute, Dehra Dun. The results of these studies have been reviewed in the present paper.

On the basis of physical and mechanical properties, _E. tereticornis_ has been found to be 10% heavier, 15% harder and 15% higher in shock resisting ability in comparison to teak. However, it has been found to be 25% weaker than teak in strength Under machining operations, it has been found that this species can be very well machine planed, turned, bored or mortised. The working quality index of _E. tereticornis_ has been found to be 94 with teak as 100. The studies on seasoning, durability and treatability behaviour are in progress. However, the results obtained so far indicate that it can be seasoned well with suitable modification in sawing techniques as well as with pre seasoning chemical treatment The species belongs to non-durable and non-treatable class. With proper care _E tereticornis_ can be used for making simple as well as bentwood furniture, tool handles, pallets and many other items By proper selection the species can be used for overhead power and telecommunication line poles. It is already well known that, the eucalypts yield excellent raw material for pulp and paper. Some

trees of *E tereticornis* yield Cineole rich medicinal oil. The bark of *E. tereticornis* can be used for producing oxalic acid and can also be used for making hardboards Plywood has also been developed from the species but the results are not very encouraging. Many studies are underway to find still more and more uses of *Eucalyptus tereticornis* and the results will be available in the near future.

संकर युकेलिप्टस का समुपयोजन—एक समीक्षा

लेखक एस०एस० राजपूत व एम०सी० तिवारी

सारांश

युकेलिप्टस टेरेटिकार्निस जिसका लोक प्रचलित नाम संकर युकेलिप्टस था मैसूर गम है, क्रमिक पंचवर्षीय योजनाओं के रोपण कार्यक्रमों के अन्तर्गत भारत भर में सर्वत्र विस्तृत क्षेत्र में लगाया जाता रहा है। यद्यपि अधिकांश रोपवन लुगदी और कागज के लिये लगाये गये हैं जिनके लिए इस वृक्ष जाति से अतिउत्तम कच्चा माल प्राप्त होता है, बहुधा अन्य प्रयोजनों के लिये इसकी उपयुक्तता के विषय में भी प्रश्न उठाए गये हैं। इन विभिन्न प्रयोजनों के लिये इसकी उपयुक्तता विनिश्चित करने के लिये विगत में वन अनुसन्धान सस्थान, देहरादून में कुछ अन्वेषण किए गए तथा कुछ अन्वेषण अभी भी चलाये जा रहे है। इन अध्ययनों के परीणामों की समीक्षा इस अभिपत्र में की गई है।

भौतिक और संधारी विशिष्टताओं के आधार पर यु० टेरेटिकार्निस सागौन की तुलना में 10% अधिक भारी, 15% अघिक कठोर तथा धक्का प्रतिरोध क्षमता में 15% अधिक समर्थ पाया गया है। तथापि मजबूती में यह सागौन से 25% कमजोर पाया गया। मशीनी प्रक्रियाओं में पाया गया कि यह वृक्ष जाति मशीन द्वारा बहुत सुगमता से रंदी, खरादी छिद्रित तथा चूलकाटी जा सकती है। यु० टेरेटिकार्निस का कार्यगुण निर्देशांक सागौन को 100 मानने पर 94 ही पाया गया। इसके संशोषण, टिकाऊपन और उपचार्यता व्यवहार पर गवेषणा चल रही है। तथापि, अब तक प्राप्त हुये परिणामों से संकेत मिलते हैं कि इसकी चिरान करने की रीति में उपयुक्त फेर बदल करके तथा संशोषण—पूर्व रासायनिक उपचार कराने पर इसका भली भांति संशोषण किया जा सकता है। यह काष्ठ जाति अटिकाऊ अनुपचार्य वर्ग की है। उचित सावधानी बरतने पर यु० टेरेटिकार्निस का उपयोग सादा तथा मोड़े काष्ठ का उपस्कर औजारों के बेंटे, यन्त्र प्रक्षेप (pallets) तथा अन्य वस्तुएं बनाने के लिये किया जा सकता है। उपयुक्त चुनाव करके यह काष्ठ जाति शीर्षोपरि बिजली और दूर संचार पारेपण खंभों के लिये उपयोग की जा सकती है। यह तो जाना ही जा चुका है कि युकेलिष्टसों से लुगदी और कागज बनाने का अत्युत्तम कच्चा माल प्राप्त होता है। यु० टेरेटिकार्निस के कुछ वृक्षों से सिनियोल सम्पन्न औषध तेल भी मिलता है। यु० टेरेटिकार्निस की छाल से आक्जैलिक अम्ल तथा कठोरफलक बनाने के लिए काम में लाई जा सकती है। इस काष्ठ जाति से स्तरकाष्ठ भी बनाया गया हैं, परन्तु उसके परिणाम उत्साहप्रद नहीं रहे। यु० टेरेटिकर्निस के अधिकाधिक अन्य उपयोग मालूम करने के लिये बहुत से अन्य अध्ययन अभी चल रहे हैं और निकट भविष्य में उनके परिणाम शुलभ हो जाएंगे।

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A STUDY ON THE GROWTH AND COPPICING CAPACITY OF *EUCALYPTUS TERETICORNIS* (MYSORE GUM) IN 10 YEAR OLD PLANTATION

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Introduction

Mysore gum (*Eucalyptus tereticornis*) a native of Australia has been planted on a large scale under varying adaphic and climatic conditions in India under various plantation programmes. Because of its rapid growth hardiness and immunity from cattle damage, it can be raised in lands unsuitable for cultivation to provide small wood, fuel, mannure, leaf etc. It can also be grown on cultivated lands as its shade is not heavy. The property of yielding pulp wood, timber and fuel, along with the above quality it characterises itself as a most suitable species for social forestry, farm forestry and canal bank plantation *Eucalyptus tereticornis* is also suitable for afforestation in quarry and burrow pits which are extensively exploited because of its hardiness (Rao, 1979).

Since it has a rapid growth, large scale plantations were raised to fill up the gap of supply and demand of fuel, small wood, poles and pulpwood by working on short rotations of 5-8 years. Due to various biotic, climatic and adaphic factors in different regions neither the expected growth nor yield was obtained in various plantation, posing a serious management problems. The heterogenecity in height and diameter growth added to these problems in the management of Mysore gum plantations.

Since age could not be taken as a lone factor in its managements an experiment to assess and study the growth and coppicing capacity of Mysore gum as influenced by various diameter classes in 10 years old plantations was taken up as per design and suggestions of Eucalyptus Research Centre, Hydrabad.

Material and Methods

The experiment was conducted on ten year old plantation of *E. tereticornis.* Seeds for this plantation were obtained from FRI, Dehra Dun and raised in polythene bags and planted in the field in July, 1968, at a distance of 2 m × 2 m in the premises of, Regional Forest Research Centre, Jabalpur. The area of plantation is nearly plain with gentle slope to the South and South-west. The soil is moderately deep loam with gravels and sub-soil of murrum. For this experimental studies the trees were felled on 28.6.79 by cross out saw. The height of stool was kept 15 cm from ground level. Diameter of stump height were recorded after felling the trees. Trees were classified into diameter classes as per availability of trees. Each diameter class represents one treatment.

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Treatment	*Diameter class (cm)*
T1	0 to 2
T2	2.1 to 4
T3	4.1 to 6

In each treatment thirty trees were measured and coppiced. Each treatment replicated into three replications, thus each treatment in each replication contain 10 trees. No weeding, clearing and irrigation was given to the plantation. The area was fenced for the protection from cattle. Data on number of coppice shoots thrown were recorded in September, 1979. Data on number of coppice shoot, height and diameter growth were recorded in June, 1980 and 1981.

Results and discussion

The felling was done on 28.6.79 the first coppice shoots appeared on 18.7.79 and all the stumps threw coppice shoots by 25.8.79. In September, 1979 after 3 months of coppicing the trees, the average number of coppice shoot per tree was 8, 7 and 5 in treatment T3, T2 and T1 respectively. In June, 1980 the average number of coppice shoot was naturally reduced to 7 from 8 in treatment T3 (Table 3), where as the average number of coppice shoots in treatment T2 and T1 remained 7 and 5 as it was in 1979. However, in June, 1981 the average number of coppice shoots naturally were reduced in all the treatment and become nearly equal i.e. 4 (Table 3). This reduction in the number of coppice shoots was due to the drying up of small and thinner coppice shoots which could not compete with the healthy and vigourous coppice shoot from the same stump.

Table 1 indicates that average height growth of coppice shoot in T3 (2.69 mt.) is significant over both T2 (1.97 mt.) and T1 (0.93 mt.).

Average maximum height growth of coppice shoot in T3 (3.86 mt.) is significant over T1 (1.21 mt.) and T2 (2.88 mt.) Table 1.

Eucalyptus tereticornis

Coppicing Capacity of *Eucalyptus tereticornis*

Table 1

	Before coppicing			After coppicing			
Treat-ment	Diam. in cms (D.B.H.) June, 1979	Av. D.B.H. in cm June, 1979	Av. ht. in mt. June, 1979	Av. diam. of stump at the time of coppicing June, 1979	Av. ht. of coppice shoot June, 1980	Av. ht. of coppice shoot June, 1981	Av. maxi. ht. of coppice shoot June, 1981
T1	0-2	0.95	3.49	2.75	0.75	0.93	1.21
T2	2.1-4	3.05	4.92	5.39	1.17	1.97	2.68
T3	4.1-6	4.91	6.25	8.10	1.64	2.69	3.86
SEM ±		0.25	0.95	0.20	0.22	0.62	0.79

Significant at 5% level.

In general average diameter at breast height (Table 2) in treatment T3 (1.98 cm) is significant over both T2 (1.57 cm) and T1 (1.06 cm).

Table 2
Average D.B.H. of coppice shoot in cms after coppicing

Treatment	Av. D B.H. otf coppice shoot June, 1979	Av. D.B.H. of coppice shoot June, 1980	Av. max. D B H. June, 1981
T1	0.35	1.06	1.15
T2	0.57	1.57	2.41
T3	1.05	1.98	3.30
SEM ±	0.25	0.64	1.00

Significant at 5% level.

Table 3
Average Nos. of coppice shoots

Treatment	Av. nos. of coppice shoot Sept., 1979	Av. nos. of coppice shoot June, 1980	Av. nos. of coppice shoot June, 1981
T1	5	5	4
T2	7	7	4
T3	8	7	4
SEM ±	1.09	1.00	—

Significant at 5% level.

The average maximum diameter in treatment T3 (3.30 cm) is significant over both the T1 (1.15 cm) and T2 (2.41 cm). These finding confirm that the diameter of stool size at the time of coppicing effects the height and diameter growth of coppice shoot. The results will therefore have a far reaching effect on the management and exploitation of coppice regeneration and rotation of *Eucalyptus tereticornis* plantation in various parts of the State.

SUMMARY

Coppicing experiment was conducted in different sizes of diameter classes 0-2 cm, 2.1 cm to 4 cm and 4.1 cm to 6 cm in *Eucalyptus tereticornis* in ten year old plantation The average number of coppice shoot thrown by the stump of all the diameter classes was nearly equal. The height and diameter of coppice shoot was significantly higher in the stumps of larger diameter. The results will therefore have a far reaching effect on the management and exploitation of coppice regeneration and rotation of *Eucalyptus tereticornis* plantation in various parts of the State.

दस वर्षीय रोपवनों में युकेलिप्टस टेरेटिकार्निस (मैसूर गम) की वृद्धि और स्थूणरोह निकालने का अध्ययन

लेखक वी०आर० नीले, ए०के० शाह व ए०एस० भण्डारी

सारांश

दस वर्षीय युकेलिप्टस टेरेटिकार्निस रोपवन में 0 से 2 सेंमी, 2.1 सेंमी० से 4 सेंमी० तथा 4.1 सेंमी० से 6 सेंमी० व्यास वर्गों के विभिन्न आकारों पर स्थूणरोह परीक्षण आयोजित किये गये। सभी व्यास वर्गों के स्थूणों से निकले हुए स्थूण प्ररोहों की औसत संख्या लगभग बराबर रही। बड़े व्यास के ठूंठों (स्थूणों) में स्थूणरोहों की ऊंचाई और व्यास सार्थकत: अधिक रहे। अत: इन परिणामों का इस राज्य के विभिन्न भागों में लगाये हुये युकेलिप्टस टेरेटिकार्निस रोपवनों का प्रवन्ध करने, स्थूण पुनर्जननों का समुपयोजन करने तथा आवर्तन निर्धारित करने में दूरगामी प्रभाव पड़ेगा।

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SOMATIC MULTIPLICATION IN *EUCALYPTUS CAMALDULENSIS* THROUGH LEAFY CUTTINGS

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Introduction

The very well established importance of vegetative propagation of ornamental and horticultural species has developed many techniques which aid in maintaining the desired characteristics of the mother plant at economic and commercial level The exploitation of the qualitative and quantitative economic traits with special reference to fruits, flowers etc are highly correleted with the success of the technique for its vegetative propagation.

In forestry these techniques have started playing a significant role since the time of commencement of Genetic Improvement Work With a number of positive and negative points, keeping in mind the problems with regard to environment, monoculture etc , these techniques can be explored for different important tree species under limitation. The use of somatic multiplication can be suggested in forestry as follows :

1. The retention of the desired genotype and its propagation under control conditions and production of base material for somatic multiplication whenever needed.
2. Early flowering at workable height for the use of breader to develop a step ahead improved seed through controlled or uncontrolled hybridization using a perfect design.
3. Large scale planting under Social Forestry, Agro-Forestry and Farm Forestry programmes using multiclones or the specifically prescribed variety.

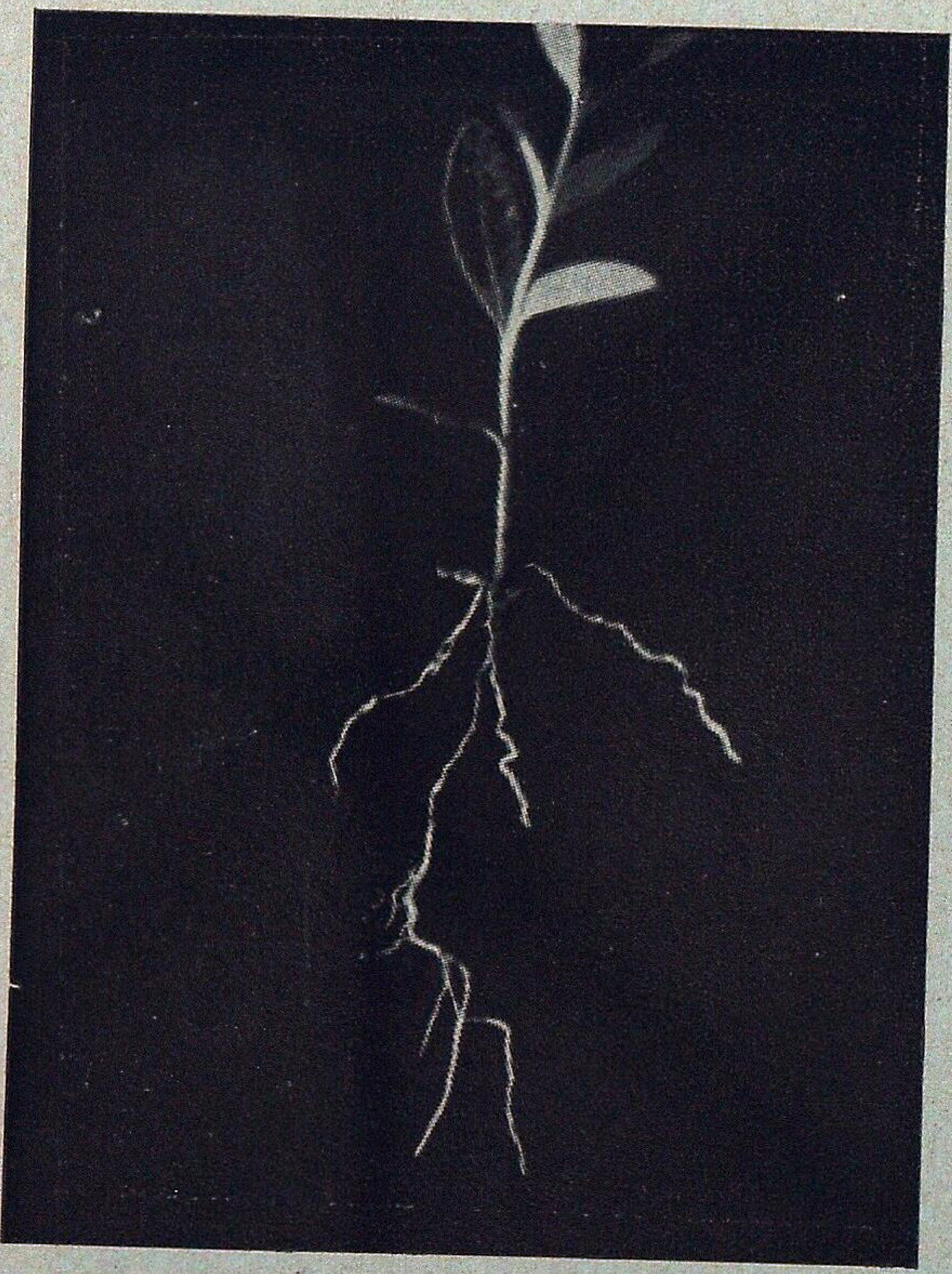
In forestry most work has been done for the establishment of Seed Orchard and the success obtained with the species are *Alder, Ash, Aspen, Beech, Birch, Fir, Larch, Oak, Pine, Spruce* etc. (Wright, 1976). In India a significant success in vegetative propagation has been achieved. Lohani *et al.* (1980) list approximately 69 forest tree species where the cuttings can be rooted. They also mention the use of leafy cuttings for rooting in case of *Acer, Carpnus, Cryptomeria* and *Quercus* species. In *Pinus patula* and *P. roxburghii* the grafting success has been obtained upto the extent of cent per cent (Kapoor *et al.* 1977, Kedharnath *et al* 1979)·

The *Eucalyptus* have been found to be difficult to vegetatively propagate (Nanda, 1970; Paulas, 1981). Though the grafting is not a complete failure but this success always have been observed leading to graft-incompatibility on the other hand rooting of cuttings tried in different species of *Eucalyptus* have not shown any encouraging result.

Fig 1

Cutting showing developing roots

Fig. 1



Cutting showing developing roots.

The mention of successful vegetative propagation in *E. tereticornis* has been made by Bhatnagar and Joshi (1973) through lignotubers and by Paulas (1981) by seeding suckers (1981). The present paper deals with the encouraging success in rooting of cutting of *E. camaldulensis* together with the suggestions in operating future contribution to commercial planting programmes under Social and Industrial Forestry.

Material and Methods

The seed of *E. camaldulensis*, single tree belonging to petford provenance planted in 1967 together with 11 other provenances in a small provenance trial at New Forest, was collected in 1982. The seedlings were raised in earthen pots and outplanted in June, 1983.

Twenty sister plants were randomly selected for a small experiment on rooting of cuttings. The average height of the selected plants was 1.20 m. The top 10 cm of every plant was cut enabling the plant to produce side branches. These side branches, the tender leafy cutting, of varied length from 5 cm to 10 cm were plucked and planted in polypots containing garden soil only. It is important to note that no treatment of root promoters or controlled conditions of temperature and humidity were supplied to them. These polypots with the cuttings were kept in open and were watered regularly to keep the soil moist. Viewing the effectiveness of temperature and humidity in earlier conducted experiments on vegetative propagation the present experiment was run for four months from July to October, 1983.

Result and Discussion

The establishment of the cuttings was visualized by their apical growth. And when 3-5 new leaves emerged and expanded the cuttings where observed for the possible rooting. The rest of cutting were observed wilting within 3 to 7 days. The amount of rooting differed but not measured (Fig. 1). The success of rooting is tabulated in Table 1.

Table 1

Duration of cutting planting	No. of cutting planted	No. of cuttings survived after 40 days.	Percentage of success in rooting of cutting
July, 1983	100	40	40
August, 1983	100	80	80
Septembe , 1983	100	60	60
October, 1983	100	30	30

From the Table 1 it can be noticed that *E camaldulensis* responded very well for rooting during the months of Aug. and Sept., 1983. Former and later months to this time period suffered with a sudden decline in this behaviour. Comparing the climatological data (Table 2) obtained from Forest Influences Branch, F.R.I. & Colleges it can be understood that the success can be obtained with such leafy cuttings round the year if the temperature and humidity are under control. The low temperature caused in bringing down the success together with the low rate of growth.

Table 2

Meteorological Data

Month	Temperature°C			Relative humidity %		R F. mm.
	Max.	Min.	Mean	07 hrs	1400 hrs	
July, 1953	31.6	22.2	26.4	88	68	323 2
August, 1983	30.4	23.4	26.1	94	76	689.5
Sept., 1983	30.7	22.2	25.8	93	70	346.1
Oct., 1983	28.6	14.6	21.1	92	50	41.8

E. camaldulensis is a sister species of *E. tereticornis*. Both of them belong to same series Macrantherae with a high potential of crossability. Both the species produce lignotubers. The effectiveness of lignotubers in vegetative propogation of plants has been utilized in *E. tereticornis* by Bhatnagar and Joshi (1973) and by Paulas (1981) in two different ways. Discussing the genetic improvement programme in eucalypts conventionally adopted all over the world, Eldridge (1975) summarises the task of vegetative multiplication to create the seed orchards for comparatively better seed. The rooting of cuttings is certainly more economic and safe than the commonly practised method of grafting which consumes the time and manpower alongwith the possibility of the failure in future due to graft incompatibility. Pryor cited by Eldridge (1975) could induce coppice shoots from the basal 15 centimeter of three-year-old of *E. regnans* plantation and 50% strike under mist spray quite readily. Paulas (1981) has found the observation of Pryor true with *E. tereticornis* and instead of coppice shoot has used the term seedling suckers. However, for non-coppicing eucalypts vegetative propagation remains a problem. In view of the previous work on somatic propagation in *Eucaluptus* the present findings are highly economical and can be adopted in commercial production of vegetative offsprings. It is expected that these results will not differ significantly if the leafy shoots are taken after cutting the top of the side branches or pollarding the mature trees.

This technique will aid foresters multiplying the selected phenotypes and assembling them in an orchard for genetically improved seed collection. This can also be used in clone multiplication of the heterotic FRI-4 and FRI-5 the inter specific crosses (Venkatesh & Sharma, 1977) for its clonal trial under different conditions as the so called F_2 seed from them will be of much inferior quality then the F_1 seed. The technique if adopted on large scale will aid in supplying the desired clones of FRI-4 and FRI-5 for commercial planting under Social Industrial and Farm Forestry Programmes.

SUMMARY

Viewing the increasing demand of eucalypts planting under various recently developed programmes. this article presents the importance of somatic multiplication through rooting of cuttings in *Eucalyptus camaldulensis*, enabling the scientists to conserve & multiply the plus phenotypes and varieties developed and the consumer to harvest the best in shortest possible span of time.

पर्णयुक्त कलमों द्वारा युकेलिप्टस कैमेलड्युलेंसिस का तनु-कोशा बहुलन कराना

लेखक रजनीश के० वक्षस्य व एम०एस० रावत

सारांश

विभिन्न विकास कार्यक्रमों के अधीन युकेलिप्टस लगाने के पदार्थ की बढ़ती हुई मांग को देखते हुए यह लेख युकेलिप्टस कैमेड्यूलेंसिस की कलमों में तनू-कोशा बहुलन द्वारा जड़ें निकलवाने का महत्व प्रदर्शित करता है। जिससे वैज्ञानिक विकसित हुए श्रेष्ठतर (प्लस) समरूपों और विभेदों को संरक्षित कर सकेंगे तथा उपभोक्ता कम से कम समय के भीतर अच्छे से अच्छे माल की कटाई कर सकेंगे।

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NUTRIENTS REMOVAL FROM *EUCALYPTUS* PLANTATIONS BY HARVESTING WOOD

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Introduction

Various management practices and silvicultural operations are employed by forester for sustained biomass production depending upon the forest type, climate, soil type etc. In plantation crops the biomass components that are removed while harvesting, influence the fertility status of the soil. Maximum drain of nutrients from the soil occurs through wood harvesting (Carter, 1974, and George, 1977). In the previous article (George, 1983) distribution of organic matter and plant nutrients in three ten-years old *Eucalyptus hybrid* plantation situated in Tarai Bhabar, Pilibhit and East Dehradun Divisions of Uttar Pradesh were described. Details of the plantations studied are given in Table 1. The present article provides informations regarding biomass production and nutrient removal by harvesting wood from these plantations and its implication on soil fertility is discussed.

Material and Methods

Sample plot of size 0.1 ha was laid out in all the plantations and the whole diameter range was stratified into four diameter classes. An average tree of each stratum was sampled and green weight of all above ground biomass (a.g.b.) components were recorded. In plantation No. 3 only two trees were felled and thus total 10 trees were sampled. Dry weight of trees were estimated from the samples collected and oven dried at 85°C. Samples were analysed for N, P, K, Ca and Mg using standard methods (Vogel, 1961).

Biomass production

The basic data obtained from three ten-years old *E. hybrid* plantations and described in the previous article (George, 1983) are reproduced in Table 2 for ready reference.

Table 1

Details of plantations studied

Locality	Soil type	Spacement (feet)	Age (yrs)	Av. height (m)	Av. D.B.H.	Density (trees/ha
Tarai Bhabar	Alluvial	10 × 10	10	18.98	14.6	992
Pilibhit	Sandy loam	12 × 6	10	19.23	15.9	1023
East Dehradun	Clay loam	12 × 6	10	16.71	14 4	1133

Table 2

Dry matter distribution in sample trees (kg)

Pl. No.	Trees No.	D.B.H. (cm)	Height (m)	Leaf	Twig	Branch	Bark	Wood	Total	Root
	1	9.4	12.5	2.1	2.0	3.9	4.2	16.6	28 8	—
1	2	12.8	16.9	2.4	3.4	7.3	10.3	51.8	75.2	15.8
	3	16.0	19.8	5.6	4.1	6.3	16.8	83.9	116.7	—
	4	19.3	26.2	7.3	5.3	19.5	30.3	226.2	288 6	—
	1	10.1	13.0	1.2	1.4	4.4	2.4	22.1	31.5	—
2	2	15.7	20.7	4.1	4.0	10.1	16.9	84.2	119.3	—
	3	19.3	20.0	8.4	8.3	17.9	17.1	129.3	181.0	29.4
	4	24.5	25.0	8.8	14.5	26.5	33.1	250.1	333.0	—
3	1	12.4	16.0	3.9	6.1	9.6	8 3	40.9	68.8	—
	2	16.4	22.0	5.0	4.6	13.0	16 0	105.3	143 9	20.9

The biomass production on unit area basis (kg/ha) was obtained by multiplying the dry weight of sample trees with number of trees in the respective diameter class and then converting into unit area basis. The results are furnished in Table 3.

Table 3

Dry matter production by various tree components in E. hybrid plantations (kg/ha)

Pl. No.	Leaf	Twig	Branch	Bark	Wood	Total
1	4434 (3.5)	3718 (3.0)	9267 (7.3)	15495 (12.3)	93187 (73.9)	126101
2	4873 (3.6)	5700 (4.2)	13928 (10.2)	13442 (9.8)	98683 (72.2)	136626
3	4947 (4.1)	6069 (4.9)	12807 (10.6)	13764 (10.4)	82804 (68.8)	120391

Note : Values in bracket indicate the percentage to total a.g.b.

It is observed that the total above ground biomass (a.g.b) varies from 120391 kg/ha (density 1133 trees/ha to 136626 kg/ha (density 1023 trees/ha) of which 69 to 74% is constituted by wood followed by 10 to 12% by bark, 7 to 11% by branches. 3 to 5% by twigs and about 4% by leaf. The average annual accumulation of dry matter in the non photosynthetic a.g b is given in Table 4. On a unit area basis the average annual accumulation is 12166 kg/ha/yr, 13175 kg/ha/yr and 115444 kg/ha/yr in plantation 1, 2 and 3 respectively. On a per tree basis the values are 12.3 kg, 12.4 kg and 10.2 kg respectively. Kaul *et al* (1979) estimated the productivity of Sal (*Shorea robusta*) coppice plantation of age 21 years as 7.7 which is lesser than that of the present study. This is under-standable, since *E. hybrid* is a fast growing species, the average annual production will be more than that of *S. robusta* which is a slow growing species.

Table 4

Average biomass production and productivity of 10 years old E. hybrid plantations at different localities

Component	Lacalities		
	Tarai Bhabar	Pilibhit	Dehradun
Non-photosynthetic a.g b. (kg/tree)	122.6	128.8	101.9
Photosynthetic biomass (kg/tree)	4.5	4.8	4.4
Total a.g.b. (kg/tree)	127.1	133.6	106.3
Productivity			
Non-photosynthetic a.g.b. (kg/ha/yr)	12166	13175	11544
Non-photosynthetic a.g.b. (kg/tree/yr)	12.3	12.4	10.2

Nutrients accumulation in the standing crop

The nutrients accumulation in the various tree components on a unit area basis (kg/ha) is given in Table 5. These values were obtained by using the actual nutrient concentration of the sample tree components. The nutrients accumulated is directly proportionate to the biomass produced and the concentration of different nutrient elements in the various tree components. It is observed that among the various nutrients, accumulation of Ca is the highest in all the plantations followed by N, K, Mg and lowest by phosphorous. With regards to the nutrient contents in the biomass components, wood has the highest amount of all nutrients except for Ca which is in the bark (Table 5). Values obtained by Cromer *et al.* (1976) for accumulation of N and P in the above ground biomass of *E. globulus* in Australia, are much lower than that of the present study, mainly due to the low concentration of N and P in various tree components of *E. globulus* and also due to the low biomass production (kg/ha) of the species in Australia. The percentage of various elements in different components is furnished in Table 6. In all the plantations studied,

43 to 44% of total N, 48 to 50% of total P, 31 to 35% of total K, and 37 to 47% of total Mg is accumulated in the wood. Bark contained 69 to 77% of total Ca, 19 to 28% P, 22 to 30% K, 24 to 37% Mg and 12 to 20% N. The balance were shared by leaves, twigs and branches. Results of similar studies carried out by Seth *et al.* (1963) in plantations of *Tectona grandis*, *Pinus roxburghii*, and *Dendrocalamus strictus* indicate that, major portion of total N and P, K and Mg was accumulated in wood and Ca in bark which was also found in the present study.

Table 5

Nutrients accumulation in the standing crop of E. hybrid plantation (kg/ha)

Pl. No.	Nutrients	Leaf	Twig	Branch	Bark	Wood	Total
	N	97	16	35	81	179	408
1	P	7	4	8	23	40	82
	K	43	19	23	71	79	235
	Ca	64	44	76	797	51	1032
	Mg	14	11	18	60	59	162
	N	86	25	53	56	174	394
2	P	8	7	18	19	48	100
	K	46	26	42	81	88	283
	Ca	67	63	142	609	44	925
	Mg	16	19	32	43	68	178
	N	109	26	41	48	168	392
	P	8	6	10	23	47	94
3	K	52	30	45	64	104	295
	Ca	67	69	154	745	47	1082
	Mg	11	4	14	26	48	103

Table 6

Pe-centage of total uptake of nutrients accumulated by different above ground biomass components

Pl. No.	Nutrients	Leaf	Twig	Branch	Bark	Wood
1		23.7	3.9	8.6	19.9	43.9
2	N	21.8	6.3	13.5	14.2	44.2
3		27.8	6.6	10.5	12.2	42.9
1		8.5	4.8	9.8	28.1	48.8
2	P	8.0	7.0	18.0	19.0	48.0
3		8.5	6.4	10.6	24.5	50.0
1		18.3	8.1	9.8	30.2	33.6
2	K	16.3	9.2	14.8	28.6	31.1
3		17.6	10.2	15.2	21.7	35.3
1		6.2	4.3	7.3	77.3	4.9
2	Ca	7.2	6.8	15.4	65.8	4.8
3		6.2	6.4	14.2	68.9	4.3
1		8.6	6.8	11.1	37.0	36.5
2	Mg	9.0	10.7	18.0	24 1	38.2
3		10.7	3 9	13.6	25.2	46.6

Since these plantations would be exploited mainly for wood by paper and pulp industries, the present results show that by clear felling 10 years old plantation, 31 to 50% of the total uptake of various nutrients (N, P, K, and Mg) would be removed through wood alone while removal of calcium through wood harvesting is very small (5%). The result of present study also suggest that since bark accumulates appreciable quantities of various nutrients and will not be used by pulp and paper industries, it should necessarily be left to the forest floor decomposition so that 12 to 30% of total uptake of various nutrients will be allowed to recycle but will only reduce 10 to 12% biomass.

Jorgensen *et al.* (1975) reported that, by removing wood alone, one thirds as much nutrients as total tree harvest is taken away, but yields two thirds as much biomass They have also reported that, by removing debarked wood, takes about 20% less N, P and K from the site than a normal Pulpwood harvest and reduce the weight yield by only 10%. Investigations carried out in different *Eucalyptus* species in several Italian stations showed that even the greatest nutrients removal by *Eucalyptus* are inferior to those of highly demanding agricultural crops where by it is possible to affirm that *Eucalyptus* cultivation does not deteriorate site productivity. Therefore, mineral fertilizer is necessary only in case

of nutrient poor soils (Lubrano, 1967). Studies conducted in *E hybrid* plantations in India show that, substantial amount of nutrients are returned to the soil through litter fall, stemflow and throughfall (George, 1978, 1979, 1982). Input of various nutrients by way of geo-chemical cycle and other means like biological fixation of nitrogen and gains of nitrogen from atmosphere which are active in tropical areas along with biological cycle would compensate any loss of nutrients by wood harvesting and justify the introduction of *E. hybrid* for large scale plantations. However, the results of the present study are also a pointer that some safe guards in terms of fertilization may be necessary to maintain the yield from second and subsequent rotations.

Acknowledgements

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SUMMARY

Biomass production and nutrients accumulation in three ten years old *Eucalyptus hybrid* plantations located in Tarai Bhabar, Pilibhit and East Dehradun divisions of Uttar Pradesh were estimated. The wood (under bark) production was 93187 kg/ha (992 trees/ha), 98683 kg/ha (1023 trees/ha) and 82804 kg/ha (1133 trees/ha) which formed 69 to 74% of total above ground biomass. Maxium accumulation of N, P, K and Mg was observed in wood where as that of Ca was in bark. The results indicate that by clear felling ten years old plantations, of the total uptake, 43 to 44% of N, 48 to 50% of P, 31 to 35% of K and 37 to 47% of Mg is removed by wood harvesting alone. Nutrient removal by various biomass components and its implication on soil fertility is discussed.

लकड़ी कटाई करने पर युकेलिप्टस—रोपवनों से पोष्याहार निकलना

लेखक एम० जार्ज

सारांश

उत्तर प्रदेश के तराई-भाबर, पीलीभीत और पूर्वी देहरादून वन मण्डलों में लगे हुये तीन दस वर्षीय संकर युकेलिप्टस रोपवनों में जैवपुंज उत्पादन और पोष्याहार एकत्रण का आकलन किया गया। कुल काष्ठ (छाल के नीचे) उत्पादन 93187 किग्रा/हिक्टे० (992 वृक्ष/हिक्टे०) 98683 किग्रा/हिक्टे० (1023 वृक्ष/हिक्टे०) और 82804 किग्रा/हिक्टे० (1133 वृक्ष/हिक्टे०) हुआ जो भूमि के ऊपर के कुल जैवपुंज का 69 से 7-% तक बना। नाइट्रोजन, फास्फोरस, पोटाश और मैगनीशियम का सबसे अधिक जमाव लकड़ी में पाया गया जबकि कैलशियम छाल में अधिक था। परिणामों से संकेत मिलता है कि दस वर्षीय रोपवन का निशेष पालन करने से पोष्याहार के कुल ग्रहण में से 43 से 44% नाइट्रोजन, 48 से 50% फास्फोरस, 31 से 35% पोटाशियम और 37 से 47% मैगनीशियम लकड़ी कटाई करने से ही निकल जाती है। जैवपुंज के विभिन्न संयोगांगों द्वारा पोष्याहार, निकलने और मृदा उर्वरता पर उसके प्रभावों की विवेचना भी की गई है।

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STUDIES ON THE EFFECT OF ETHYLMETHANE SULPHONATE ON *EUCALYPTUS TERETICORNIS* X *E. CAMALDULENSIS* FOR EVOLVING MUTATION BREEDING METHODS

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Introduction

Mutations can be induced artificially through irradiations or chemical mutagenesis. Artificial Mutations will prove fruitful under certain conditions, and in the long run it may be one of the methods needed when forest trees are dealt with (Gustafsson, 1962). The pre-requisites to develop mutation breeding methods are : (1) knowledge on the sensitivity of the material to find out the suitable doses/concentrations and duration of treatment, (2) method of treatment, (3) parameters to be included which respond efficiently to the treatment and (4) marker characters as indicators of the effect of treatment and consequently mutations. Genus *Eucalyptus* is a widely planted fast growing tree species and much in demand by the Indian farmers and industries. Thus there is a need to develop different methods for the genetic improvement of this genus which fortunately is also a most suitable test material for breeder's point of view. Seeds of *Eucalyptus* hybrid namely FRI-4 which is a cross between *E. tereticornis* and *E. camaldulensis* were treated with Ethylmethane sulphonate (EMS) a super chemical mutagen (Rapoport *et al.* 1966) and the results of these studies are reported in this paper which eventually will be useful for developing mutation breeding methods and help in tree improvement programmes.

Materials and Methods

Mutagenicity of monofunctional EMS was studied by treating dry and pre-soaked seeds of FRI-4 with EMS. Biological response to the mutagen treatment was measured through the expression of parameters namely Germination, Germination value (GV), Hypocotyl length, Radicle length, Cotyledon width and length, Green and Dry weight of seedlings and Chromosomal abnormalities.

Seeds of FRI-4 were treated with different concentrations of EMS solution, in two lots. In the first lot Air-dry seeds were soaked for 18 hours in EMS solution prepared using buffer tablets (pH-7) under the concentrations—0.25, 0.50, 0.75 and 1.00%. Volume of EMS solution used in each vial was 15cc in all the treatments. The second lot of seeds was pre-soaked in distilled water for 8 hours and then soaked in their respective concentrations of EMS for 10 hours. After treatment with EMS the seeds were thoroughly washed in water

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and kept for germination in the seed germinator on water moist germination paper at a temperature of 32±2°C and 85±5% humidity. For comparison seeds were soaked only in buffer solution (pH-7) for their respective durations to serve as control. The seeds were sown in five replications per dose. For each dose an additional replication was sown for cytological studies, the root tips of which were fixed in 1 : 3 Acetic Alcohol and after 48 hours transferred in 70% Alcohol. Root tip squashes were made to score bridge formations at anaphase using aceto-carmine stain.

Daily germination count was recorded till completion of germination. Germination value (GV) was calculated according to F.J. Czabator (1962). After two weeks of germination, observations were recorded on different parameters viz : seedling height, cotyledon width and length and green and dry weight, to assess the effect of EMS on them. Reduction percentage for different parameters was calculated taking control as 100 to obtain information on lethal doses of EMS. Analysis of variance (ANOVA) was carried out on the different parameters to see whether differences due to treatment of EMS are significant or not when compared with control.

Results and Discussion

Air-dry Seeds. Germination of air-dry seeds of FRI-4 after treating with EMS was drastically affected as there was no germination beyond 0.25%. Though there was 11.11% reduction at 0.25% EMS, 100% reduction was observed at 0.25% which shows that the threshold limit of concentration of EMS to cause total biological injury in the case of air-dry seeds is very narrow (Table 1). The reduction in GV was 64.18% which is indicative that speed of germination was drastically affected at 0.25% EMS. Delay in germination may be due to the inhibitory effect of EMS on the activity of the embryonic cells causing delayed germination (Raghuvanshi and Singh, 1981) possibly as a result of the action on enzyme system The reduction percentage in the length of hypocotyl and radicle was 29.18 and 50.00% respectively, which shows that radicle was more sensitive to EMS in comparison to hypocotyl. When width and length of cotyledons was considered the reduction values were 14.28 and 6.67% respectively. Air-dry seeds of FRI-4 were found to be more sensitive to EMS while compared with the results on *Pinus roxburghii*, *P. patula*, *Eucalyptus alba* and *E. grandis* which were treated with similar concentrations of EMS earlier at this Laboratory (Kapoor, 1981). Pines were more sensitive in comparison to *Eucalyptus* species, however all the four species could tolerate EMS upto 1.00% concentration with variation in reduction values within the different parameters. Whereas in the case of FRI-4 under present studies, concentrations beyond 0.25% were lethal. When green and dry weight of the seedlings were considered, it was observed that there was 17.64% reduction in dry weight and 11.93% in the case of green weight at 0.25% concentration (Table 3). Root tip squashes observed at anaphase did not show chromosomal abnormalities. The observations have indicated that GV and Radicle are the most sensitive parameters.

Pre-soaked Seeds. Seeds of FRI-4 pre-soaked in distilled water for 8 hours and in EMS solution for 10 hours were found to tolerate EMS upto 1.00% concentration. When germina-

tion, germination value, hypocotyl and radicle length, and green dry weight and bridges at anaphase were considered, variation in the reduction values of different parameters, under different concentrations of EMS used (Table 2) was observed. However, in general there was a positive correlation between concentrations of EMS and reduction values. Maximum reduction percentage was observed at 1.00% concentration in all the parameters. The lowest EMS concentration used (0.25%) was not essentially the concentration showing the minimum effect in terms of reduction percentage in the different parameters as stimulation was also observed in the parameters – germination, germination value and hypocotyl length. Stimulation ing ermination and hypocotyl length was observed under 0.50% concentration also This observation agrees with the work done on other forest tree species (Kapoor, 1981) where stimulation in lower doses was observed (El-Lakany and Sziklai, 1975). More studies are required on stimulation and its control to use this effect for increasing the wood production in tree species. In green and dry weight (Table 3) no specific trend was observed in the reduction values between the different concentrations. Bridges observed at anaphase of root tip squashes showed a linear trend with 1.11% at 0.50% concentration through 5.88% at 1.00% concentration (Table 4) Such abnormalities have also been reported in the case of *Dalbergia sissoo* following a linear trend where 4.60% of abnormal cells were observed at 0.45% EMS (Haque *et al*, 1982).

Conclusions

Based on the present and earlier studies with forest tree species (Kapoor, 1981) it may be inferred that Germination value (GV) is one of the most important and sensitive parameters to be included in the experiments to be conducted with EMS because GV gives information on both the speed and completeness of germination. Pre entation of only germination may not be sufficient to give a clear picture about the sensitivity of the species under study, as it has also been observed in the case of other species of *Eucalyptus* (Kapoor, 1980) where upto 1.00% concentration of EMS seeds germinated equal in number to the untreated control. But the effect of EMS was reflected only through GV or other parameters at a later stage of development. Radicle length is another parameter which is very sensitive to the treatment of EMS and must be recorded because the ultimate survival and growth of treated seedlings has a direct correlation with the development of root system. Air-dry seeds were found to be more sensitive to EMS in comparison to pre-soaked seeds, which is reverse of the findings of Savin *et al.* (1968), in barley where pre-soaked seeds were found to be more sensitive.

These studies have suggested that EMS is a powerful chemical mutagen and the condition of the seed (dry or pre-soaked) before treatment may help in manipulating the effectivity of EMS. Chromosomal bridges at anaphese caused by EMS treatment could be recognized as indicators for the treated material having been genetically disturbed. From all the parameters studied, GV, radicle length and chromosomal abnormalties from root tips have proved to be the most sensitive parameters and could be selected for assessing sensitivity to EMS. These findings will be very useful for guiding mutation breeding work in tree species.

Table 1

Mean values of different parameters after treating Dry seeds of FRI-4 with Ethylmethane sulphonate (EMS).

Parameters	Actual Mean ± SE					F value after ANOVA
	EMS %					
	Control	0.25	0.50	0 75	1.00	
G	72.00	64.00	0.00	0.00	0.00	
	*5.83	*2 45				160.36***
R	(0.00)	(11.11)	(100)	(100)	(100)	
GV	191.66	68 65	0.00	0 00	0.00	
	*34.38	*11.19				25.01***
R	(0(.0)	(64.18)	(100)	(100)	(100)	
HL	1 68	1 19	0.00	0.00	0.00	
	*0 10	*0 06				187 57***
R	(0.00)	(29.18)	(100)	(100)	(100)	
RL	0.58	0.29	0 00	0.00	0.00	
	*0.06	*0.08				70.33***
R	(0.00)	(50.00)	(100)	(100)	(100)	
CW	0.28	0.24	0.00	0.00	0.00	
	*0.02	*0.01				112.00***
R	(0.00)	(14.28)	(100)	(100)	(100)	
CL	0.15	0 14	0.00	0.00	0.00	
	*0.07	*0 008				41.12***
R	(0.00)	(6.67)	(100)	(100)	(100)	

G = Germination %. GV = Germination value. HL = Hypocotyl length. RL= Radical length. CW = Cotyledon width. CL = Cotyledon length. R = Reduction % within parenthesis. *** =Significant at 0.1% level. * Denotes ±

Table 2

Mean values of differnt parameters after treating Pre-soaked seeds of FRI-4 with Ethylmethane sulphonate (EMS)

Parameters	Actual Mean ± SE					F. value after ANOVA
	EMS %					
	Control	0.25	0.50	0.75	1.00	
G	70.00	89.00	72.00	68.00	52.00	
	*5.77	*2.41	*3.74	*2.00	*7.35	5.47**
R	(0.00)	(+22.85)	(+2.85)	(2.85)	(25.7)	
GV	156.87	164.71	123.79	61.63	28.86	
	*34.11	*17.14	*9.82	*3.79	*7.47	11 27***
R	(0 00)	(+4.99)	(21.08)	(60.71)	(81.60)	
HL	1.55	1.59	1.64	1.32	0.87	
	*0.08	*0 08	*0.08	*0.09	*0.07	22.99***
R	(0.00)	(+2.58)	(+5.81)	(14.84)	(43.87)	
RL	0.55	0.49	0.41	0.21	0.13	
	*0.05	*0. 2	*0.03	*0.01	*0.02	3[illegible].11***
R	(0.00)	(10.91)	(25.45)	(61.82)	(76.30)	
CW	0.27	0.24	0.23	0.22	0.19	
	*0.007	*0.02	*0.008	*0.02	*0.02	5.00**
R	(0.00)	(11.11)	(14.81)	(18.52)	(29 63)	
CL	0.17	0.15	0.13	0.13	0.11	
	*0.007	*0.01	*0.006	*0.007	*0.004	9.33**
R	(0.00)	(11.76)	(23.53)	(23.53)	(35.29)	

G = Germination %. GV = Germination values.
HL = Hypocotyl length. RL = Radicle length.
CW = Cotyledon width. CL = Cotyledon length.
R = Reduction % within parenthesis. + = Stimulation.
* Denotes ±
** = Significant at 1 % level.
*** = Significant at 0.1 % level.

Table 3

Mean values in milligrams of green and dry weight of seedlings after treating Dry and Pre-soaked seeds of FRI-4 with Ethylmethane sulphonate

Parameters	Condition of seed	EMS %				
		Control	0.25	0.50	0.75	1.00
CW	DS	4.26	3.76	0.00	0.00	0.00
	R	(0.00)	(11.93)	(100)	(100)	(100)
	PS	4 20	3.57	4.20	3.47	2.47
	R	(0.00)	(15.00)	(0.00)	(18.54)	(42 01)
DW	DS	0 30	0.28	0.00	0.00	0.00
	R	(0.00)	(17.64)	(100)	(100)	(100)
	PS	0 36	0 25	0.23	0.20	0.36
	R	(0.00)	(30.55)	(36.11)	(27.77)	(0.00)
Moisture content of seedlings.	DS	3.92	3.48	0.00	0.00	0.00
	R	(0.00)	(11.22)	(100)	(100)	(100)
	PS	3 84	3.32	3.97	3.21	2 11
	R	(0.00)	(13.54)	(+3.99)	(+16.41)	(45.05)

DS = Dry seeds. PS = Pre-soaked seeds. GW = Green weight.
DW = Dry weight. R = Reduction % within parenthesis.
+ = Stimulation.

Table 4

Bridges observed at anaphase of root tips squashed after treating Pre-soaked seeds of FRI-4 with Ethylmethane sulphonate (EME)

EMS %	Total dividing cells scored	Total Bridge scored	Bridges %
Control	95	0.00	0.00
0.25	90	0.0	0.00
0.50	90	1.0	1.11
0 75	90	3.0	3 33
1.00	85	5.0	5 88

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SUMMARY

Air dry and pre-soaked seeds of *Eucalyptus* (FRI-4) were treated with different concentrations of Ethylmethane sulphonate (EMS) for framing methods and techniques for mutation breeding programme. The effect of EMS was assessed on the basis of different parameters viz. Germination, Germination value, Hypocotyl and Radicle length, Cotyledon length and width, Green and Dry weight and Chromosomal abnormalities at anaphase. Air-dry seeds were found to be more sensitive to EMS in comparison to pre-soaked seeds. Stimulation was observed in a few parameters at low concentrations. Germination value, radicle length and mitotic divisions were found to be the most sensitive parameters. These findings will be very useful for guiding mutation breeding work in tree species.

उत्परिवर्ती प्रजनन रीतियां विकसित करने के लिये युकेलिप्टस टेरेटिकार्निस, यु० कैमेलड्लेंसिस पर इथाइलमीथेन सल्फोनेट के प्रभाव का अध्ययन

लेखक कुमारी रेणु स्वरूप व एम०एल० कपूर

सारांश

उत्परिवर्ती प्रजनन कार्यक्रमों की रीति और प्रविधियां तैयार करने के लिए युकेलिप्टस (एफ० आर० आई 4) को इथाइलमीथेन सल्फोनेट के विभिन्न संकेन्द्रणों से उपचारित किया गया। इथाइललमीथेन सल्फेनेट के प्रभावों का आकलन विभिन्न परिमापों अर्थात् अंकुरण, अंकुरण अर्हा, अधोबीजपत्र और शालिका की लम्बाई, बीजपत्र की लम्बाई और चौड़ाई, हरा और शुल्क भार तथा भाजनोत्तर अवस्था में गुण सूत्रीय असामान्यताएं द्वारा आकलित की गई हैं। पहले से भिगोए हुए बीजों की तुलना में वायु शुष्क बीज इथाइलमीथेन सल्फोनेट के प्रति अधिक प्रभविष्णु पाए गए। कुछ परिमापों में निम्न संकेन्द्रणों पर भी उत्तेजन होता पाया गया। अंकुरण अर्हा, शाखिका की लम्बाई और सूत्रिभाजन सर्वाधिक प्रभविष्णु परिमाप पाए गए। ये मालूमात वृक्ष जातियों में उत्परिवर्ती प्रजनन कार्य निर्देशित करने में बड़े काम की रहेंगी।

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NUTRIENT CYCLE IN *EUCALYPTUS TERETICORNIS* SMITH PLANTATIONS

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Introduction

Estimation of the essential mineral elements both in plant and soil is an important aspect in the study of ecosystem structure. In case of fast growing species it becomes more essential to study the geochemical cycle of the essential elements in support of their survival in future. Geochemical cycle also provides a basis to evaluate the productivity of the ecosystem. In the forest ecosystem, uptake, retention and distribution of biogenic salts in the plant body is affected by several factors such as age and type of tree species, soil conditions and climate. *Eucalyptus* is considered to be a fast growing species, and has many criticisms regarding its requirements of nutrients, is being planted on large scale throughout the country by forest department as well as by farmers along their fields to meet the requirements of fuelwood and paper industry. The present investigation was taken up to study the uptake, accumulation and release through the litter fall of nitrogen, phosphorus and calcium in five different aged plantations of *Eucalyptus tereticornis.*

Geographical location of the experimental area

The study was carried out in district Muzaffarnagar of western Uttar Pradesh. The area chosen lies in the alluvial plain and forms a trough between the Himalayan in the North and Deccan Plateau in the South and situated at 29° 11′ 30″ N – 29° 45′ 15″ N and 77° 3′ 45″ E–98° 7′ 0″ E. This trough area is also known as "Doab". In the near North of this area is Siwalik hills and in the near South is Satpura, Amravati and Vindhya hills To the South-west is desert of Rajasthan whose influence is frequently felt during the summer months. The area is quite far from sea and the height above mean sea level varies between 210 to 240 m.

Meterials and methods

Five to nine years old plantatins of *Eucalyptus tereticornis* grown by Forest Department of Meerut Forest Division, Uttar Pradesh, along the main Ganga Canal sides were considered for the present study. The techniques used for biomass studies, and litter collection have already been described by Singh (1982) for the same species. To estimate nitrogen, phosphorus and calcium in different plant parts of different age groups plantations, composite samples (1000 g) were collected at the time of harvesting. These samples were analysed after grinding in a wiley mill through a 50 mesh stainless steel sieve Nitrogen was determined by microkjeldahl method. Perchloric acid, sulphuric acid and nitric acid digestates were used for calcium and phosphorus determination (Riper, 1950). Calcium was determined by method described by Misra (1968) and phosphorus was estimated by colorimetry method (Fisk and Soubarow, 1925).

Results and discussions

Nutrients percentage in different plant parts. The percentage of nutrients namely, nitrogen, phosphorus and calcium in different plant parts of sample trees is presented in Table 1. It is evident from the results that there is no definite order of nutrients concentrations in bole, branches, leaves and roots in any age group of Eucalypt plantations. The concentrations of these mineral elements do not show any consistent trend with increasing age of the tree. The relative proportions of the various elements differ considerably for different parts of the trees, for example, the percentage of nitrogen in the leaves is more than double that of phosphorus except in seven years old sample trees whilst in all the components the percentage of calcium is much more that of nitrogen and phosphorus respectively. The nutrient concentration in *E. tereticornis* is more than the coniferous Trees (Ovington, 1959), *Shorea robusta* and *Buchanania lanzan*, dominent and codominent tree species of dry deciduous forest (Sharma, 1971).

Table 1

Average nutrient concentrations in different plant parts of different aged stands of Eucalyptus tereticornis.

(Average of nine replicates)

Age (years)	Nutrients (%)	Plant parts			
		Bole	Branches	Leaves	Root
5	Nitrogen	0.51	0.46	0.96	0.28
	Phosphorus	0.24	0.23	0 29	0.29
	Calcium	3.83	3.50	4.58	3.75
6	Nitrogen	0 79	0.53	1.35	1.21
	Phosphorus	0 38	0.47	0.50	0.50
	Calcium	5.08	5.41	3.50	4.33
7	Nitrogen	1.19	0.64	0.58	0.66
	Phosphorus	0.46	0.43	0 44	0.43
	Calcium	4.16	4.50	5.41	4.41
8	Nitrogen	0.77	0.53	1.05	1.02
	Phosphorus	0.39	0.47	0 49	0 48
	Calcium	5.00	4.41	4.58	4.16
9	Nitrogen	0.58	0 51	1.07	0.32
	Phosphorus	0 32	0.29	0.26	0.29
	Calcium	3.91	3.50	5.25	4 66

The amount of Nutrients in Average trees. As the trees becoms older, increasing amounts of nutrients are incorporated within them (Table 2). This increase occurs primarily as a result of the large increase in dry weight of different plant parts. The results indicate that mineral elements are not distributed equally and also do not show increasing trend between the component parts of the trees with age because their distribution depend on both the dry weight and the average percentages of the elements in the tree parts. Ovington and Madgwick (1959) recorded the same pattern of elements distribution in different aged stands of birch. The leaves contain relatively higher concentrations of nutrients than other plant parts but on dry weight basis, accumulation of elements is more in other plant parts. Total nitrogen, phosphorus and calcium content per tree increases with rising age and girth being minimum in five year old stand and maximum in nine year old stand respectively. Maximum accumulation of nutrients was recorded in bole for all the five stands.

Table 2

Accumulation of nutrients (kg/tree) in component plant parts of different aged stands of Eucalyptus tereticornis

Age (years)	Nutrients	Plant parts				Total
		Bole	Branches	Leaves	Root	
	Nitrogen	0.176	0.030	0.040	0.018	0.264
5	Phosphorus	0.088	0.011	0 011	0.018	0.128
	Calcium	1.454	0.232	0.187	0.237	2.110
	Nitrogen	0.317	0.035	0.047	0.112	0.511
6	Phosphorus	0.198	0.033	0.018	0.046	0.295
	Calcium	2.368	0.368	0.122	0.440	3.298
	Nitrogen	0.849	0.086	0.033	0.087	1.055
7	Phosphorus	0.317	0.059	0.025	0.061	0.462
	Calcium	3.005	0.613	0.330	0.605	4.553
	Nitrogen	0.579	0.097	0.100	0.161	0.937
8	Phosphorus	0.293	0.084	0.050	0.071	0.498
	Calcium	3.454	0.854	0 449	0.540	5,297
	Nitrogen	0.843	0.149	0.092	0.061	1.245
9	Phosphorus	0 483	0.084	0.021	0.054	0.642
	Calcium	5 619	1.022	0.440	0.916	7.998

Nutrient uptake. Annual uptake of mineral content in different aged stands on per tree and per hectare basis is presented in Table 3. The nutrient content of the tree stock does not represent the gross uptake of nutrients by the tree since some trees will have died and some of the nutrients taken up by the surviving trees will have been returned to the soil in various ways. Consequently, the gross uptake of nutrients by the trees has been calculated from the estimates of total dry-matter production (Ovington and Madgwick, 1959). Annual uptake of nitrogen and calcium per tree increases with age having only exception in case of calcium of eight year old trees. On the other hand, the uptake of phosphorus increases upto seven years age than declines in subsequent older trees. Total amount of nitrogen accumulated in biomass annually is estimated to be 101.66; 119.76; 119.48; 242.51 and 182.15 kg/ha/yr for the period from 5 to 9 years respectively. In case of phosphorus the said values are 45 68; 61.60; 69.46; 131.97 and 86.48 kg/ha/yr respectively. Total amount of calcium accumulated in biomass annually is much more than that of nitrogen and phosphorus in all the five stands being 732.78; 603.29; 736.90; 1225.83 and 1260.05 kg/ha respectively. Data further reveals that the maximum nitrogen and phosphorus uptake occur in the plants of eight years old stand while maximum calcium uptake occurs in the individuals of nine years old stand.

Table 3

Annual uptake of mineral content (kg) in different aged stand of Eucalyptus tereticornis

Age (years)	Nitrogen		Phosphorus		Calcium	
	Per tree	Per hectare	Per tree	Per hectare	Per tree	Per hectare
5	0.066	101.66	0 029	45.68	0 466	732.78
6	0.131	119.76	0.069	61.60	0 665	603.29
7	0.152	119.48	0.088	69.46	0 935	736.90
8	0.160	212.51	0.086	131.97	0.827	1225.83
9	0.182	182.15	0.085	86.48	1.267	1260.05

Nutrient concentration in litter. Results of nutrients concentrations in leaf litter and non-leaf litter are set in Table 4. It is evident from data that leaf litter contains higher percentages of nutrients than non-leaf litter in all the stands. Nutrients concentrations of different species litter viz. *Tectona grandis, Terminalia tomentosa, Butea monosperma* and *Terminalia arjuna* have been studied by Singh (1968) in the deciduous forest communities at Varanasi. The nitrogen and phosphorus concentrations in the litter of above species are very much similar to the nitrogen and phosphorus of the present study but in case of *Eucalyptus tereticornis*, calcium contents are more than the above species.

Table 4

Nutrient concentration in leaf litter and non-leaf litter in different aged stands of Eucalyptus tereticornis

Age (years)	Leaf litter			Non-leaf litter		
	Nitrogen (%)	Phosphorus (%)	Calcium (%)	Nitrogen (%)	Phosphorus (%)	Calcium (%)
5	0.68	0.40	4.50	0.38	0.27	3.25
6	0.98	0.44	4.75	0.44	0.19	4.00
7	0.56	0 40	5.00	0.32	0.23	4.25
8	0.70	0.46	5.00	0.30	0.26	4.50
9	0.73	0.27	6.50	0.38	0.21	5.25

Nutrient release through annual litter fall. On the basis of the nutrient concentration of leaf litter and non-leaf litter, the amount of nutrient elements released annually has been computed and the values are set in Table 5. Nitrogen returned through litter fall per annum is 14.25; 26 0 ; 22.80; 30.50 and 34.59 kg/ha/yr respectively in five to nine years old stands. The amount of phosphorus released through litter fall in five to nine years old stands is 8.63; 11 62; 16 20; 20.86 and 13.78 kg/ha/yr respectively. *Eucalyptus* plantations release maximum amount of calcium to the soil through litter fall being 98 22; 140.85; 217.50; 248.00 and 334.55 kg/ha/yr respectively in the stands of 5-9 years age. The nutrients released through leaf litter for different forests of the world is presented in Table 6. It is interesting to compare the annual release of nutrients through litter fall in *Eucalyptus tereticornis* plantations with other forests of the world. *Eucalyptus* plantations appear to return higher amount of calcium and phosphorus than temperate hard woods, deciduous forests as well as conifers except that of *Terminalia - Shorea robusta* community of deciduous forests at Varanasi where phosphorus returned is more than *Eucalyptus tereticornis* plantations. Nitrogen release of temperate forests as well as conifers is distinctly higher than the *Eucalyptus* ptantations. In case of *Diospyros melanoxylon - Anogeissus latifolia* community and *Butea monosperma*, the release of nitrogen is comparable with that of *Eucalyptus* plantations.

A comparative account of annual uptake, retention and release of nutrients by different woody species of the world is presented in Table 7. Data reveals that annual uptake in *Eucalyptus* plantation is greater than Birch, Mixed Oak wood, *Nothofagus truncata* and Scots pine forests and only nitrogen uptake it less than *Shorea robusta* and *Tectona grandis* plantations (Faruqi, 1972). The annual release of nutrients increases with increasing age in *E. tereticornis* stands.

Table 5

Annual release of nutrients through litter fall in different aged stands of Eucalyptus tereticornis

Age (years)	Nutrients kg/ha/yr)						Total nutrients (kg/ha/yr)		
	Leaf litter			Non-leaf litter					
	Nitrogen	Phosphorus	Calcium	Nitrogen	Phosphorus	Calcium	Nitrogen	Phosphorus	Calcium
5	12.24	7.20	81.00	2.01	1.43	17.22	14.25	8.63	98.22
6	22.54	10.12	109.25	3.47	1.50	31.60	26.01	11.62	140.85
7	19.60	14.00	175.00	3.20	2.20	42.50	22.80	16.20	217.50
8	26.60	17.48	190.00	3.90	3.38	58.50	30.50	20.86	248.50
9	29.20	10 80	260.00	5.39	2.98	74.55	34.59	13.78	334 55

Table 4

Nutrient concentration in leaf litter and non-leaf litter in different aged stands of Eucalyptus tereticornis

Age (years)	Leaf litter			Non-leaf litter		
	Nitrogen (%)	Phosphorus (%)	Calcium (%)	Nitrogen (%)	Phosphorus (%)	Calcium (%)
5	0.68	0.40	4.50	0.38	0.27	3.25
6	0.98	0.44	4.75	0.44	0.19	4.00
7	0.56	0 40	5.00	0.32	0.23	4.25
8	0.70	0.46	5.00	0.30	0.26	4.50
9	0.73	0.27	6.50	0.38	0.21	5.25

Nutrient release through annual litter fall. On the basis of the nutrient concentration of leaf litter and non-leaf litter, the amount of nutrient elements released annually has been computed and the values are set in Table 5. Nitrogen returned through litter fall per annum is 14.25; 26 0 ; 22.80; 30.50 and 34.59 kg/ha/yr respectively in five to nine years old stands. The amount of phosphorus released through litter fall in five to nine years old stands is 8.63; 11 62; 16 20; 20.86 and 13.78 kg/ha/yr respectively. *Eucalyptus* plantations release maximum amount of calcium to the soil through litter fall being 98 22; 140.85; 217.50; 248.00 and 334.55 kg/ha/yr respectively in the stands of 5-9 years age. The nutrients released through leaf litter for different forests of the world is presented in Table 6. It is interesting to compare the annual release of nutrients through litter fall in *Eucalyptus tereticornis* plantations with other forests of the world. *Eucalyptus* plantations appear to return higher amount of calcium and phosphorus than temperate hard woods, deciduous forests as well as conifers except that of *Terminalia - Shorea robusta* community of deciduous forests at Varanasi where phosphorus returned is more than *Eucalyptus tereticornis* plantations. Nitrogen release of temperate forests as well as conifers is distinctly higher than the *Eucalyptus* ptantations. In case of *Diospyros melanoxylon - Anogeissus latifolia* community and *Butea monosperma*, the release of nitrogen is comparable with that of *Eucalyptus* plantations.

A comparative account of annual uptake, retention and release of nutrients by different woody species of the world is presented in Table 7. Data reveals that annual uptake in *Eucalyptus* plantation is greater than Birch, Mixed Oak wood, *Nothofagus truncata* and Scots pine forests and only nitrogen uptake it less than *Shorea robusta* and *Tectona grandis* plantations (Faruqi, 1972). The annual release of nutrients increases with increasing age in *E. tereticornis* stands.

Table 6

Annual release of nutrients through litter fall in different forests of the World

Vegetation and locality	Nutrients (kg/ha/yr)			Source
	Nitrogen	Phosphorus	Calcium	
Tectona grandis (plantation) Dehra Dun (India)	52	19	131	Seth *et al.* 1963
Shorea robusta (plantation) Dehra Dun (India)	46	9	77	-do-
Pinus sp. (plantation) Dehra Dun (India)	73	13	46	-do-
Terminalia tomentosa—*Shorea robusta* (community) at Varanasi (India)	54	28	184	Singh, K.P., 1968
Diospyros melanoxylon—*Anogeissus latifolia* (community) at Varanasi (India)	25	3	84	-do-
Butea monosperma Varanasi (India)	18	0.3	15	-do-
Scots pine (England)	125	10	49	Ovington, 1959
Spruce (U.S.S R.)	54	2.4	46	Ovington, 1965
Eucalyptus tereticornis (Plantations) Western Uttar Pradesh (India).	14.25–34.59	8.63–20.86	98.22–334.55	Present study

Table 7

Annual uptake, retention and release of nutrients by different woodland plants

Tree species and locality		Nutrients (kg/ha/yr)			Source
		Nitrogen	Phosphorus	Calcium	
1	2	3	4	5	6
Scots pine England	Uptake	139	11	56	Ovington (1959)
	Retained	14	1	7	
	Released	125	10	49	
Mixed oak wood U.S.S.R.	Uptake	92	7	102	Mina (1955)
	Retained	33	4	16	
	Released	59	3	86	
Nothofagus truncta New Zealand	Uptake	40	9.3	84	Miller (1963)
	Retained	3	6.7	10	
	Released	37	2.6	74	
Birch U S S.R.	Uptake	111	11	107	Smirnova and Dentseva (1958)
	Retained	45	6	53	
	Released	66	5	54	
Shorea robusta (40 yrs) Gorakhpur India	Uptake	338.9	36.5	379.6	Farugi (1972)
	Retained	201.0	17.9	251.2	
	Released	137.9	18.6	128.4	
Tectona grandis (40 yrs) Gorakhpur India	Uptake	478.1	90.9	686.0	
	Retained	243.5	57.6	321.7	–do–
	Released	234.6	33.3	354.3	
Eucalyptus tereticornis (5 yrs) Western Uttar Pradesh, India	Uptake	115.91	54.31	831.00	Present study
	Retained	101.66	45.68	732.78	
	Released	14.25	8.63	98.22	

(Contd.)

1	2	3	4	5	6
Eucalyptus tereticornis (6 yrs) Western Uttar Pradesh, India	Uptake Retained Released	145.77. 119.76 26.01	73.22 61.60 11.62	744.14 603.29 140.85	Present study
Eucalyptus tereticornis (7 yrs) Western Uttar Pradesh, India	Uptake Retained Released	142.28 119.48 22.80	85.66 69.46 16.20	954.40 736.90 217.50	-do-
Eucalyptus tereticornis (8 yrs) Western Uttar Pradesh, India	Uptake Retained Released	273.01 242.51 30.50	152.83 131.97 20.86	1474.33 1225.83 248.50	-do-
Eucalyptus tereticornis (9 yrs) Western, Uttar Pradesh, India	Uptake Retained Released	216.74 182.15 34.59	100.26 86.48 13.78	1594.60 1260.05 334.55	-do-

SUMMARY

The present investigation deals with the nutrients cycle in five to nine years old *Eucalyptus tereticornis* Smith plantations. Different plant parts were analysed for nitrogen, phosphorus and calcium and results are given of the amount of these elements in the leaves, branches, boles and roots. Total amount of these elements on average tree basis is also determined. Amount of nutrient released through literfall is also estimated and comparative account of annual uptake, retention and release of nutrients is prepared.

<u>युकेलिप्टस टेरेटिकार्निस स्मिथ रोपवनों में पोष्याहार चक्र</u>

लेखक आर०पी० सिंह

सारांश

प्रस्तुत अन्वेषण का सम्बन्ध युकेलिप्टस टेरेटिकार्निस स्मिथ के पांच से नौ वर्ष तक के रोपवनों के पोष्याहार चक्र से है। नाइट्रोजन, फास्फोरस और कैलशियम के लिये पादप के विभिन्न अंगों का विश्लेषण किया गया तथा पत्तियों, शाखाओं, तनों और जड़ों में मिली इन तत्वों की कुल मात्रा भी निश्चित की गई है। पत्तियां गिरने से निर्मुक्त होने वाले पोष्याहार की मात्रा भी अनुमान की गई है तथा पोष्याहारों के वार्षिक उद्ग्रहण, अभिधारण और निर्मुक्ति का तुलनात्मक ब्योरा भी तैयार किया गया है।

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EUCALYPTUS—A PERSPECTIVE

R.M. RAY

Dy. Conservator of Forests,
Eucalyptus Research Centre, Coonoor (Tamil Nadu)

'Please give me 200 *Eucalyptus* seedlings'. Don't you want any of the 30 odd species of seedlings ? We have seedlings like *Subabul*, *Bamboo* or *Tamarind*', I ask the farmer. 'No thank you', was his reply.

'I am told that *Eucalyptus* absorbs too much water'. This is a remark often heard from an urbanite or even from a farmer.

These are the two opposing views heard from the community. A large number of amateur environmentalists insist that *Eucalyptus* will bring doom The doomsayers are so vociferous that they have got a large section of public and even Governments worried about the matter. The main protagonists of *Eucalyptus*, namely the Forest Departments, have feebly defended *Eucalyptus* Inspite of the existance of large number of research organisations number the State Forest Departments they have not brought out clear evidence in favour of *Eucalyptus* especially as regards its alleged higher absorption rate of water.

Since a large number of people feel that *Eucalyptus* absorbs more water as compared to other tree species it will be only fair to tentatively acknowldge their feeling, so that controversy could be avoided.

The first question any-body asks is why not plant any one of the hundreds of species naturally found in the forest for obtaining small timber and firewood for the villager Some of these trees like *Casuarina*, *Albizzia*, *Acrocarpus*, *Subabul*, *Acacia nelotica* are indeed fast growing There are fruit yielding trees like *Jack*, *Tamarind Ber*, *Mango* and *Jamun*. There are oil yielding trees like *Neem* and *Pongamia* Why not popularise these trees instead of *Eucalyptus* and avoid the controversy ? This is indeed a difficult question to answer.

An average farmer has enough space to grow trees often he keeps his land fallow. He knows about the existence of dozens of species of trees and yet he was not growing them even on barren lands. He pays through his nose and buys timber to build his house and to make carts and implements. The reason is simple-inertia. The farmer is just not bothered about anything which takes decades to be useful to him· Planting a seedling may cost him 50 paise When it becomes a big tree after 50 years it may be worth Rs. 500 or Rs. 1,000. The reward for planting a seedling is great. But the farmer is not interested in a reward that will be paid after 50 years.

Perhaps an average farmer may be interested if someone suggests to him that here is a species which can be cut after 8 years, and not after 50 years. Even a period of 8 years is too long for him. He may hesitate. But if he finds that he could get the seedlings free of cost and doesn't have to worry about watering them or protecting them he may be eager. *Eucalyptus* is the species which could be cut in 8 years and doesn't have to be watered or protected because it is drought resistant and unpalatable to cattle. It coppices repeatedly the farmer has discovered that *Eucalyptus* is his immediate hope for poles and firewood. This is how the *Eucalyptus* has become popular.

Some large farmers have found that *Eucalyptus* is an excellent cash crop, giving better income than many other cash crops I met a farmer who has 50 acres of land but could not find labourers to raise crops, cultivate, weed and harvest them at the right time. Timely rains was always uncertain and he was constantly worried of crop failure. He had always felt that if he were to manage only 25 acres he could have grown crops properly and harvested better yield and avoided tension and anxiety of finding labourers in time and supervising them constantly. He put 25 acres under *Eucalyptus*. He grew crops in the balance 25 acres and gave better attention to his crop. As a result his profit from 25 acres was almost as much as what he got from 50 acres earlier and after 8 years he got his reward. He harvested about 40 tonnes of wood per acre and sold them for Rs. 400 per tonne and got Rs. 16,000 per acre, amounting to Rs 4 lakhs. This was a handsome profit by Indian standard. He could build a modern house and marry off his daughters thanks to *Eucalyptus*.

How did this farmer manage to supply water to his *Eucalyptus* trees. He erected bunds at every 50 feet interval. When there was heavy rainfall, sometimes as much as 10 cm on a single day nothing was allowed to run off because of the bunds. The entire water was permitted to infiltrate. The trees made use of this water for their growth. On the other hand in the nearby agricultural fields the excess water was drained off and the infiltration rate was much less The land had to be kept fallow after one crop. But *Eucalyptus* grew day by day round the year and added to the wealth of the farmer. This clever farmer simply impounded the rain water and grew *Eucalyptus* successfully and created wealth.

Some nearby farmers who were earlier sceptical about *Eucalyptus* rushed to make up for the lost time and started planting trees. A nearby Rayon grade pulp factory has assured them that they will lift upto 1.5 lakh tonnes of wood at the rate of Rs. 550 per tonne ex-factory

Now to analyse the advantages and disadvantages to the nation.

Advantages.

1. Farmers became wealthy.
2. Lops and Tops of trees were taken away by villagers for fuel.
3. Soil erosion was completely checked.

4. The wind velocity and resultant water loss due to transpiration by crops in the nearby fields was reduced.
5. The nation produced enough cloth and paper, building materials and firewood.
6. The Government realised huge excise income which would be spent on developmental works and for making the country stronger against enemies.
7. The wood-cutters and the lorry operators thrived.

Disadvantages

1. Some local agricultural leboures who were living at subsistence level had to move out and seek fresh avenues for work.
2. Production of coarse foodgrains was reduced by a few tonnes.

It could be easily seen that the advantages far outweigh the disadvantages. The loss of work for a few labourers is made up when, the income earned from production of cloth and paper is spent on different things creating fresh job opportunities. It is a only a matter of relocation of the idled labour force. Reduced food production is partially made up by more intensive farming. A highly industrialised nation like Japan is also self sufficient in rice with much less land. India can afford to divert about 5 per cent of its farm land to tree culture without straining its food position. After all agricultural land area was expanded only by extensive removal of forest in the last 4 to 5 decades.

Subabul is a close competitor to *Eucalyptus* when grown in good soil with irrigation. But *Subabul* is a poorer fuel than *Eucalyptus* and it is not yet accepted by pulp mills. If there is a good demand and value realisation for *Subabul*, perhaps the farmer would be better advised to grow *Subabul* in preference to *Eucalyptus*. In less intensive conditions *Eucalyptus* would be preferable.

People who are prepared to wait for many number of years may be asked to grow trees like *Tamarind*. *Tamarind* goes on yielding for a hundred years. and gives handsome income. If the Forest Department is one track minded and recommends only *Eucalyptus* in all situations it would only reflect poverty of ideas. The forester should find out the needs of individual farmers and suggest a number of options to him, *Eucalyptus* being one among them. *Eucalyptus* should not be thrust on a farmer without explaining its advantages and disadvantages vis-a-vis the other tree species. Then alone the public will have confidence in the competence of Forest Department.

Much of firewood available in the forest is purchased by pulp mills Most of the *Eucalyptus* plantations raised by Forest Departments are conceded to the paper and pulp factories. If the *Eucalyptus* firewood and poles are supplied to the villagers at concessional rate people would have appreciated its utility better. It appears to me that most people criticise *Eucalyptus* not because it removes too much water but because they are denied its enjoyment whereas the pulp mills which are financially strong are pampered with concessional

supply of *Eucalyptus* wood. It is high time that the Government stopped supplying *Eucalyptus* to the pulp mills. The pulp mills should formulate schemes with enough incentives to encourage the nearby farmers to grow *Eucalyptus* and buy the same from them. When people benefit from *Eucalyptus* they will not criticise it.

The rise and fall of water table is a seasonal phenomenon. During the rains the water table rises and during the dry season it falls. There is nothing morally wrong in tapping the ground water either through wells or through trees so long as the quantity drawn is permitted to be recouped Most of the water even now runs off and reaches the sea. If the entire precipitation is permitted to be infiltrated into the soil, *Eucalyptus* can be grown without straining the ground water resources. What is important is that whatever plant that is grown on land should make most efficient use of sunlight, soil and water to synthesise organic matter which commands maximum value I believe that *Eucalyptus* is an efficient converter of solar energy into wood, which is so badly required by people. If, in this process, it absorbs water from the soil one should not feel sorry for it. If *Eucalyptus* can help in efficient utlisation of water, let us grow it by all means.

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FORM IV

(See Rule 8)

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I, N.K. Mathur, hereby declare that the particulars given above are true to the best of my knowledge and belief.

Sd/-..... ....

(N. K. Mathur)
Publisher.

GAZETTE NOTIFICATIONS

F.R.I. GAZETTE

The President, Forest Research Institute and Colleges, Dehra Dun has been pleased to appoint Shri Lalji Prasad, working as Research Officer (Documentation) at the F.R.I. & Colleges, Dehra Dun, as Research Officer in the scale of Rs. 650-1200 in D.I.S. Scheme, Regional Forest Research Centre, Jabalpur under the F.R.I. & Colleges, Dehra Dun with effect from the forenoon of 11.11.1983 until further orders.

In accordance with the provisions of Rule 48 of C.C.S. (Pension) Rules, 1972 the President, Forest Research Institute and Colleges, Dehra Dun has been pleased to accept the Voluntary retirement from service of Shri S.K. Gupta, Research Officer, Forest Research Laboratory, Banglore with effect from 8th Nov., 1983 (AN).

ANDHRA PRADESH GAZETTE

Shri E Venugopala Rao, I.F.S., Conservator of Forests on deputation as Special Officer, A P. Agricultural University is promoted and appointed temporarily as Additional Chief Conservator of Forests in the office of the Chief Conservator of Forests in the existing vacancy relieving Shri T. Krishna Murthy, I.F.S. from additional charge.

KARNATAKA GAZETTE

Shri A.N. Yellappa Reddy, IFS., Conservator of Forests, Kodagu Circle, Madikeri, is appointed with immediate effect and until further orders as Conservator of Forests, Kanara Circle, Dharwad, vice Shri B.S. Parishwad, IFS., transferred.

Shri B S. Parishwad IFS., Conservator of Forests, Kanara Circle, Dharwad, is appointed with immediate effect and until further orders as Conservator of Forests, Kodagu Circle, Madikeri, vice Shri A.N. Yellappa Reddy, IFS., transferred.

Shri S.M. Chelawadi, IFS., Deputy Conservator of Forests, Karwar, is appointed with immediate effect and until further orders as Deputy Conservator of Forests, Yellapur, vice Shri N.G. Veerappa, IFS., promoted.

Shri G.B. Narveker, IFS., Deputy Conservator of Forests, Working Plans Division, Dharwad, is appointed with immediate effect and until further orders as Deputy Conservator of Forests, Karwar, vice Shri S.M. Chelawadi, IFS., transferred.

Shri M. Munireddy, IFS., Deputy Conservator of Forests, Kodagu. Madikeri, is appointed with immediate effect and until further orders as Deputy Conservator of Forests, Tumkur, vice Shri Indu B. Srivastava, IFS., transferred.

Shri Indu B. Srivastava, IFS., Deputy Conservator of Forests, Tumkur, is appointed with immediate effect and until further orders as Deputy Conservator of Forests, Kodagu, Madikeri, vice Shri M. Munireddy, IFS., transferred.

NEWS AND NOTES

We are pleased to learn that Dr. P.K. Sen-Sarma, Director, Biological Research, Forest Research Institute & Colleges has been elected Fellow of Indian Academy of Sciences which was founded by Prof. Sir C.V. Raman in 1934.

FRI Publications

FOREST RESEARCH INSTITUTE AND COLLEGES, DEHRA DUN

Indian Forest Bulletins

No. 275—*Silvics.* Environmental effects of forest in India, by R.C. Ghosh, O.N. Kaul and B.K. Subba Rao. (Symbol No. PFRI. 188) Price Rs. 3.10 or £ 3.36 or $ 1.12

Indian Forest Records

Vol. 3, No. 1–Wood Anatomy. Studies on the variation in Wood quality of *Eucalyptus tereticornis* Sm. trees grown in different plantations, Part-I—Wood specific gravity, by S.K. Purkayastha, S.P. Agarwal, R.D. Tondan and Laxmi Chauhan. (Symbol No. PFRI. 190). Price Rs. 5.50. or £ 0.64 or $ 1.98.

Other Publications

Timber Engineering Manual, Part III – Theory and practice of Timber lemella frames (Design, fabrication and erection techniques), by N.J. Masani. (Symbol No. PFRI. 176) Price Rs 22.00 or £ 2.56 or $ 7.92.

Indian Woods : Their identification, properties and uses, Vol. IV–Myrtaceae to symplocaceae, by S.K. Purkayastha. (Symbol No PFRI. 177) Price Rs. 145.00 or £ 16.91 or $ 52 20.

Field indentification of fifty important timbers of India, by K. Ramesh Rao & K.B.S. Juneja (Reprinted 1983) (Symbol No. PFRI. 197) Price Rs. 10.00 or £ 1.17 or $ 3.60.

Abridged glossary of technical terms (For use in Forest Colleges). (Reprinted 1983). (Symbol No. PFRI. 193) Price Rs. 9.00 or £ 1 05 or $ 3.24.

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2. **The Deputy Conservator of Forests (Depot Division) Andamans Govt. Timber Depot, 3-A, 2nd Floor, Auckland Place, Calcutta—17.**

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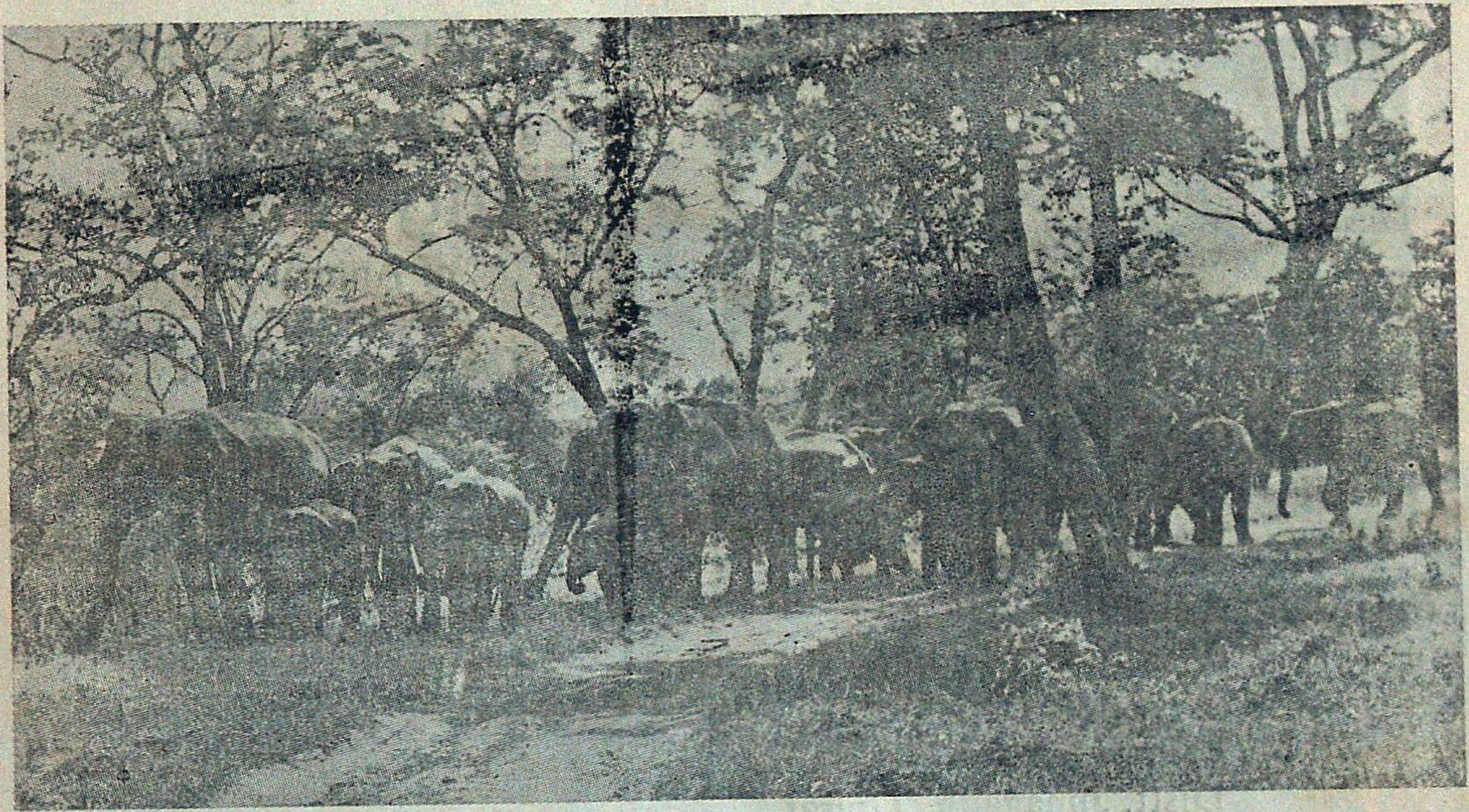

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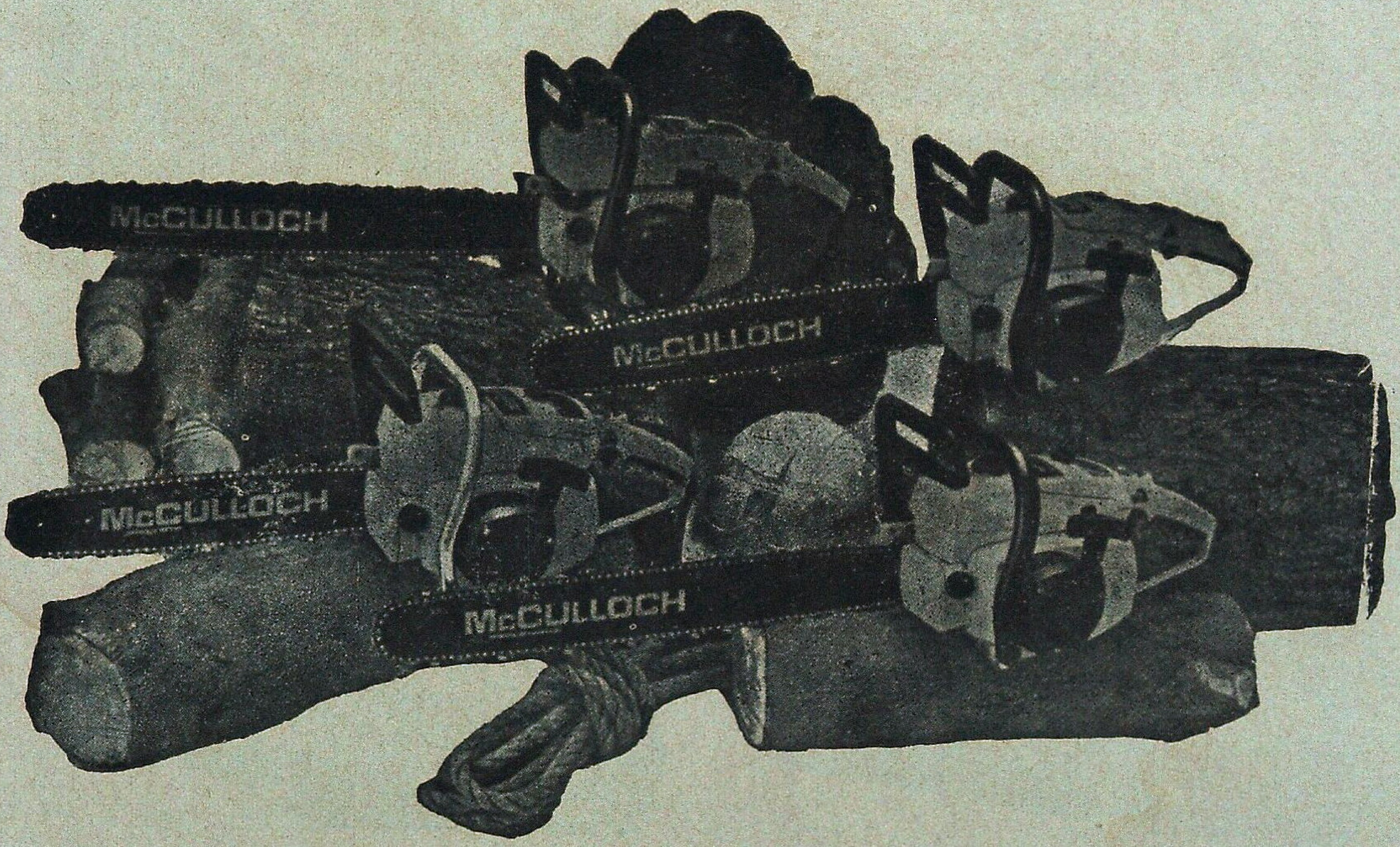

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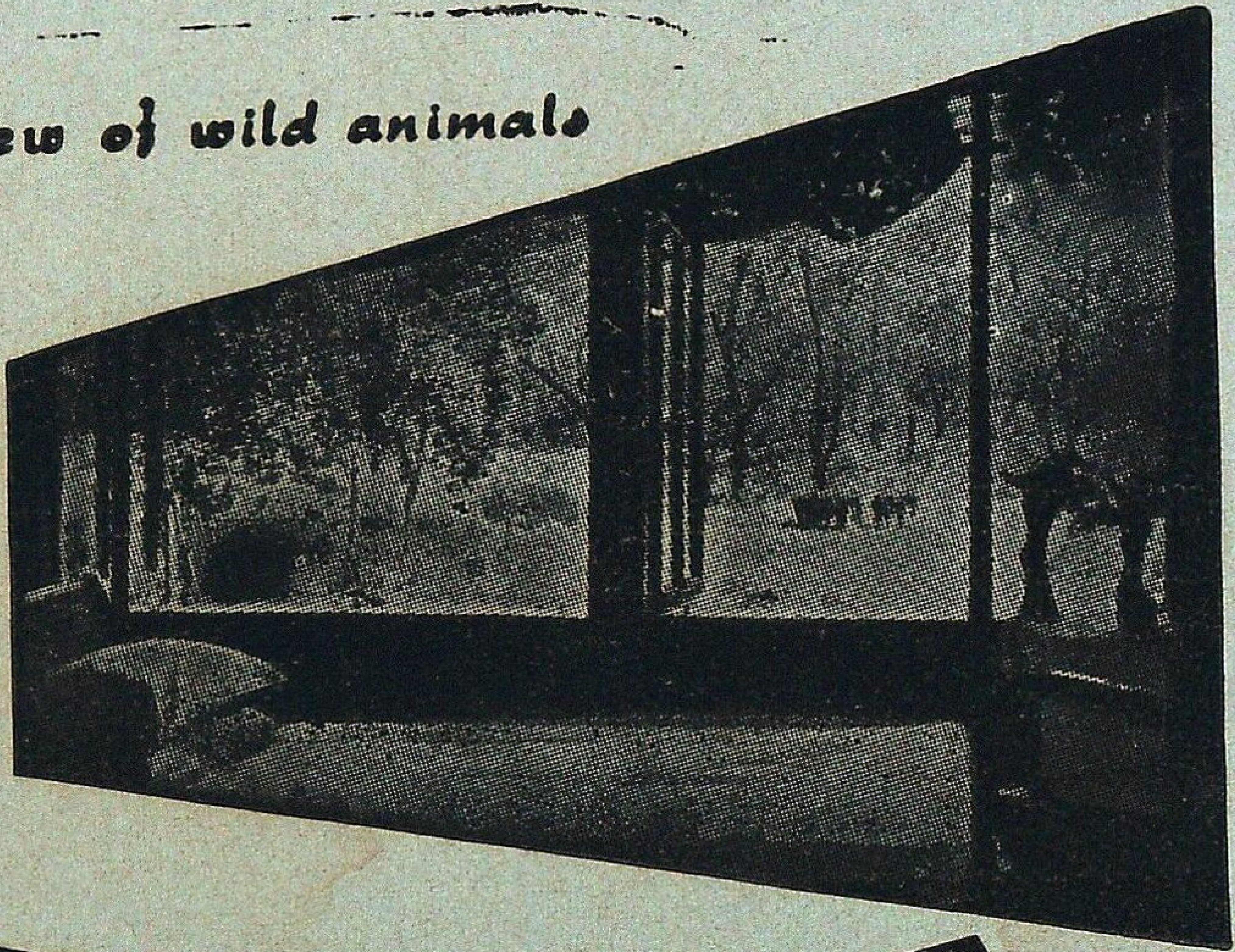

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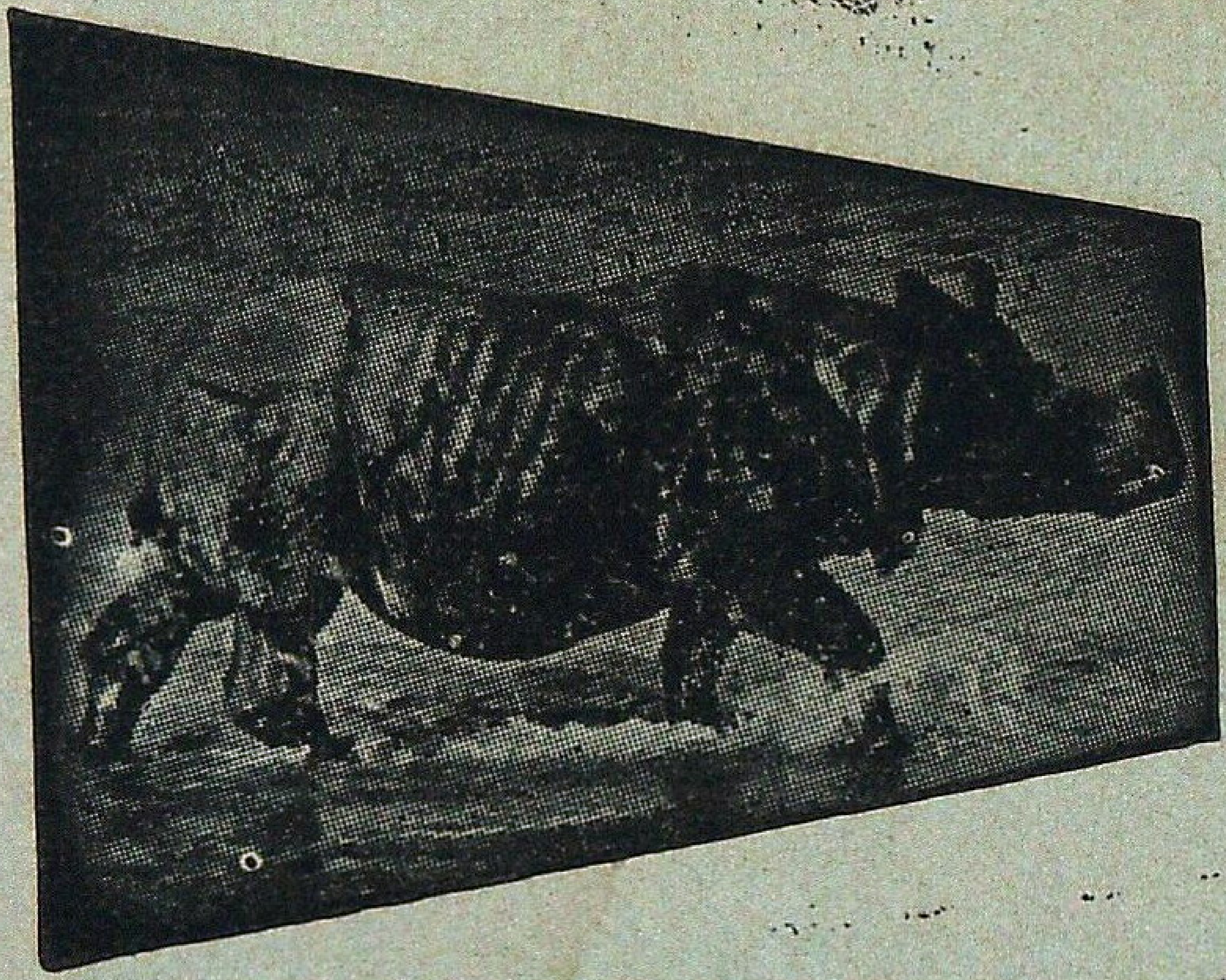

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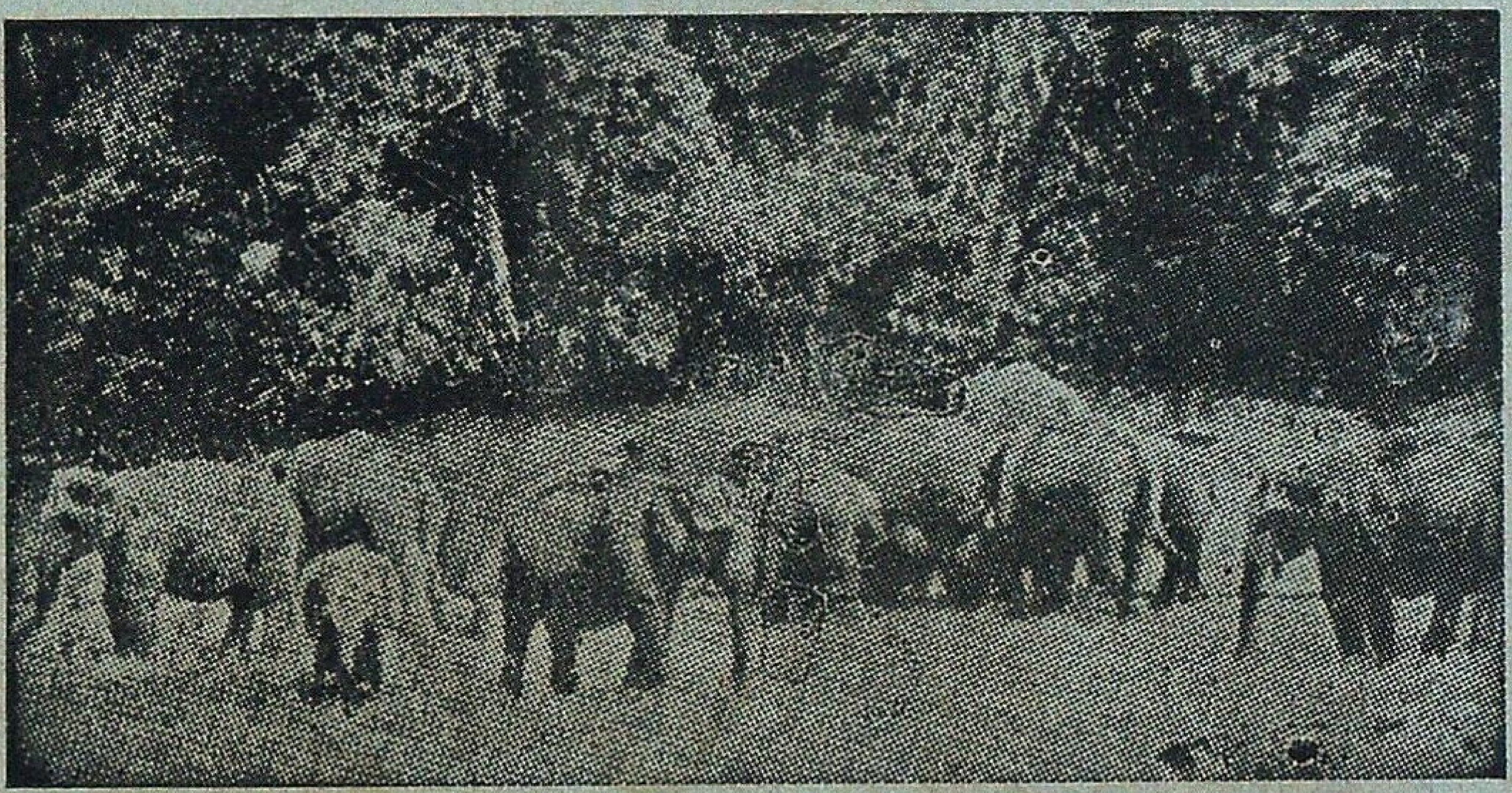

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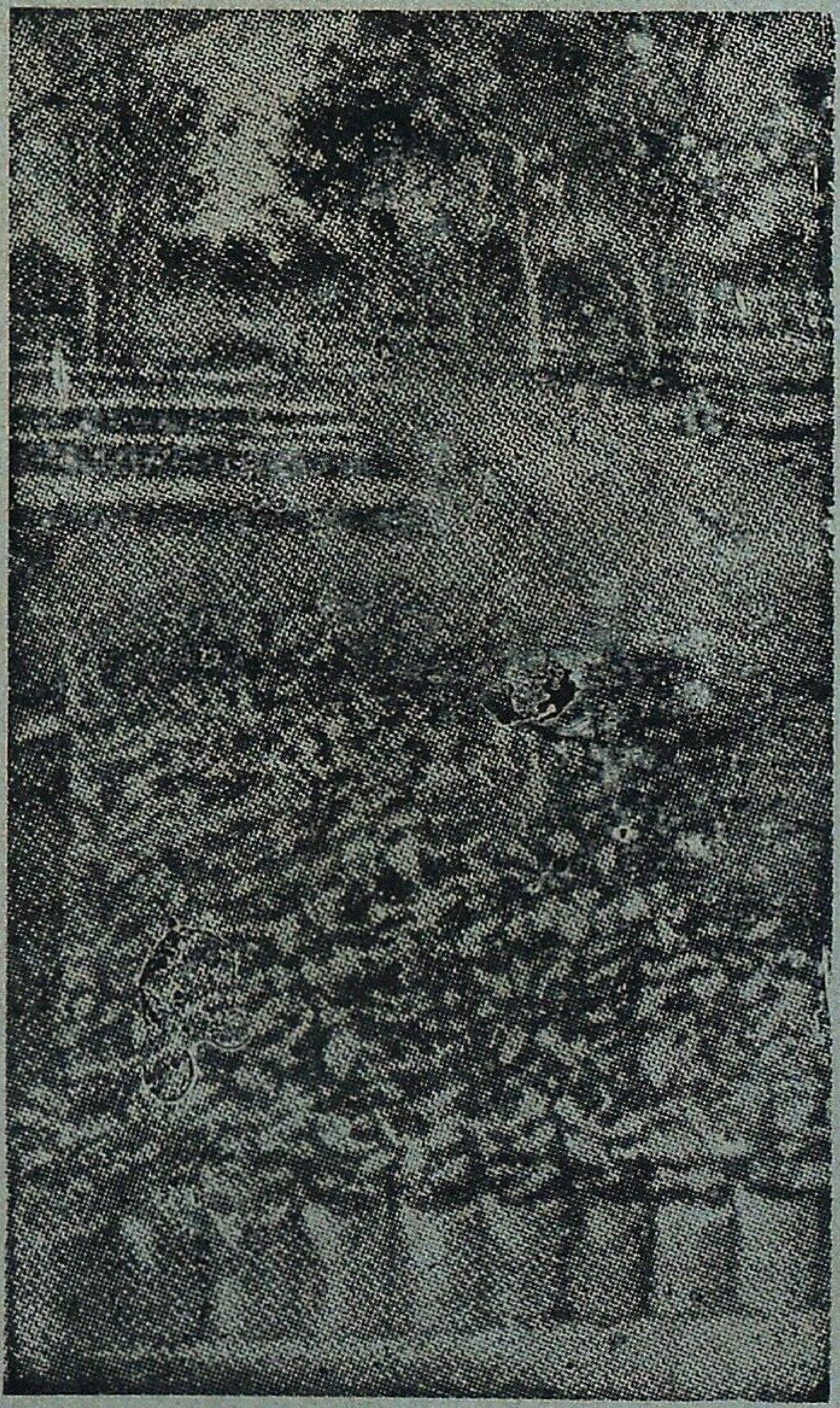

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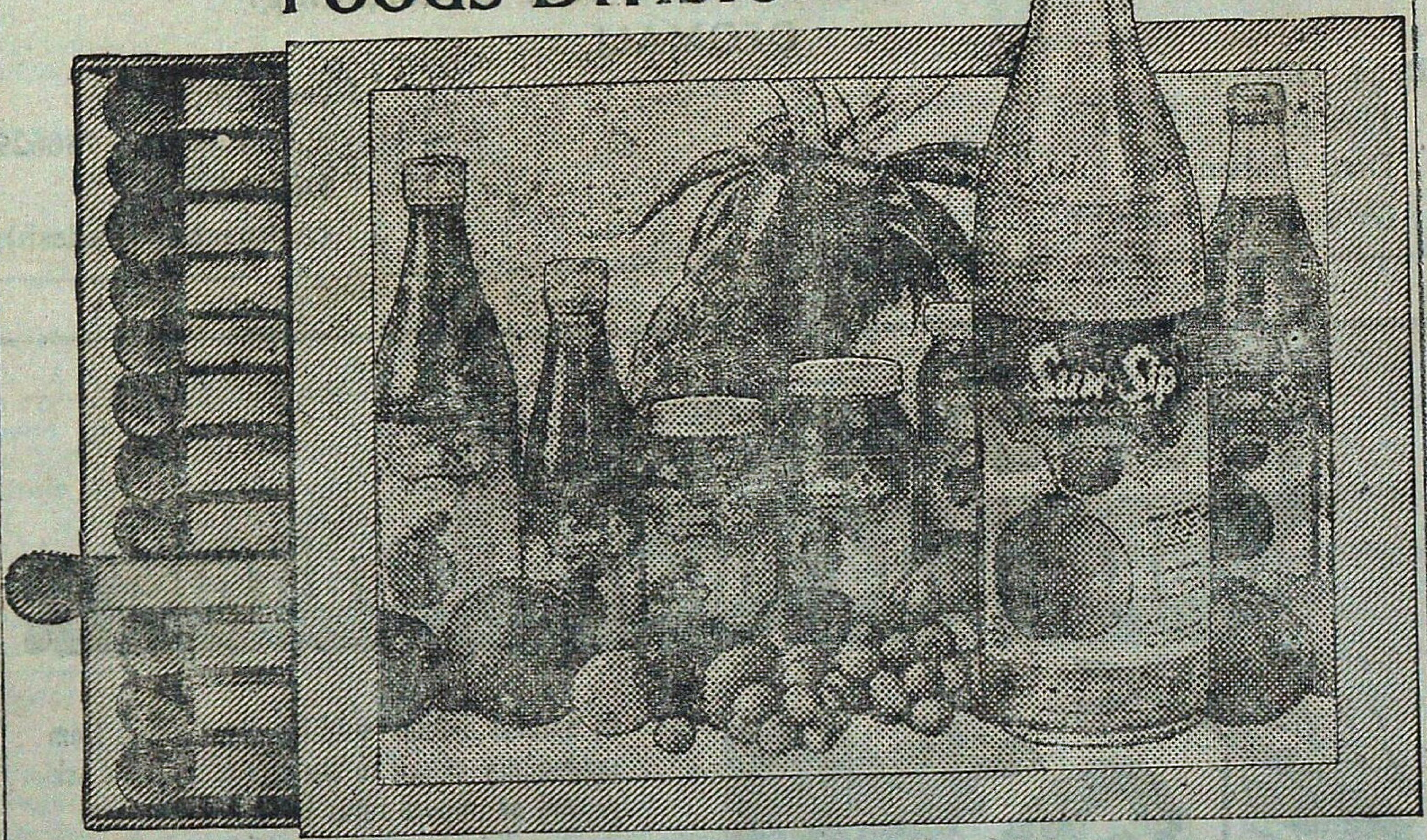

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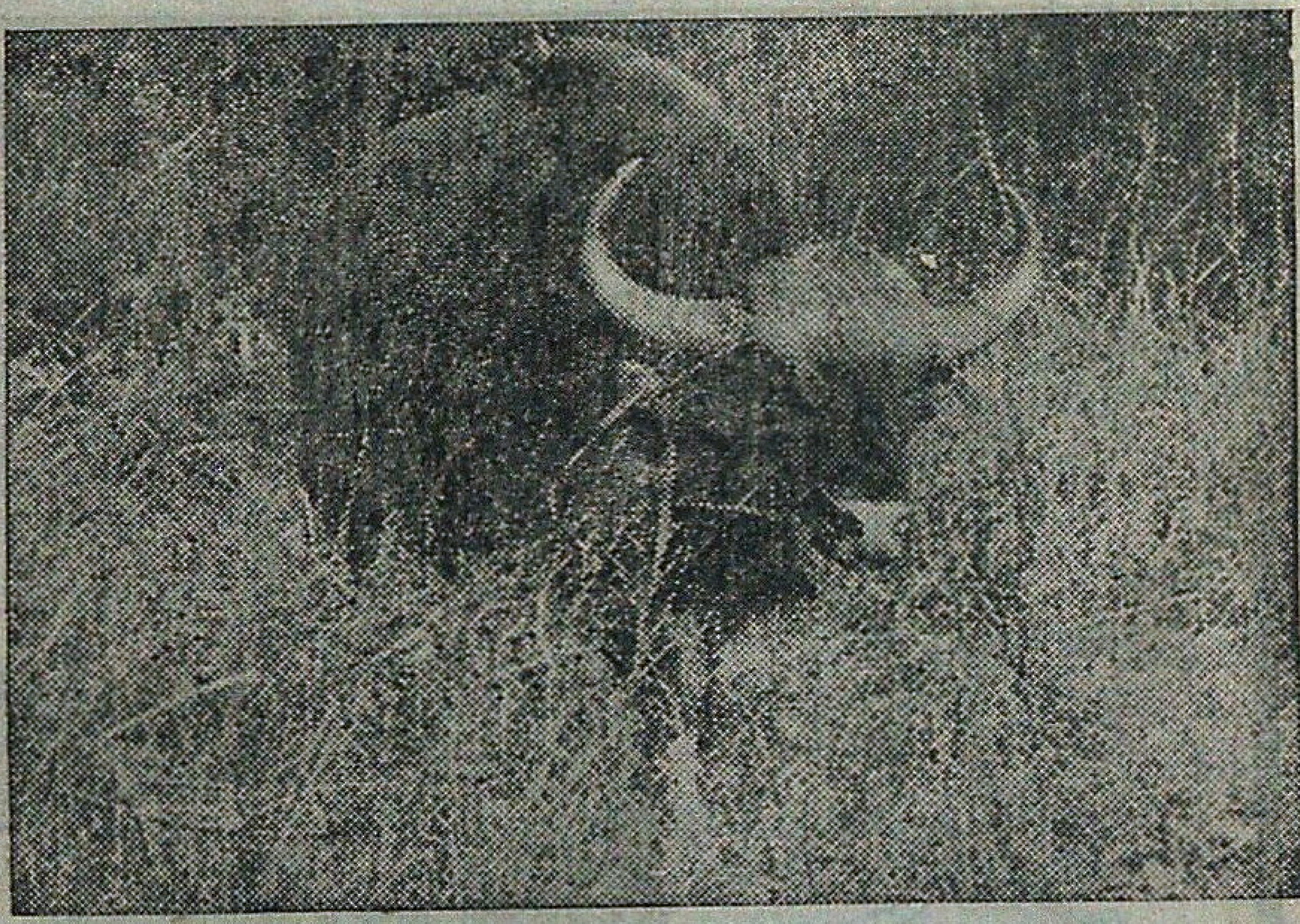

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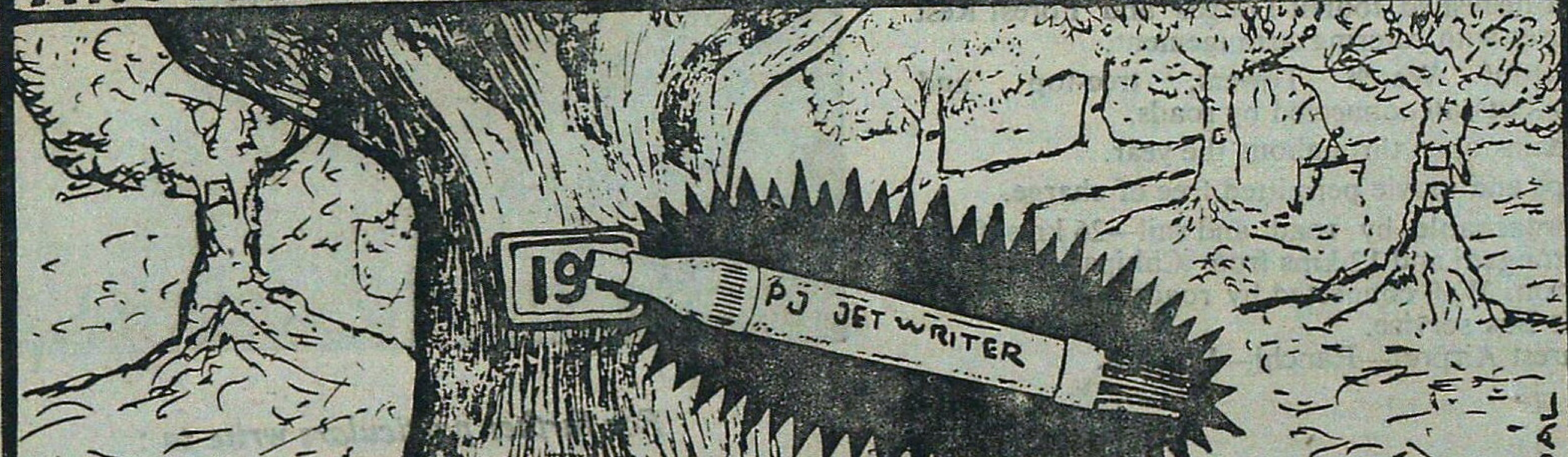

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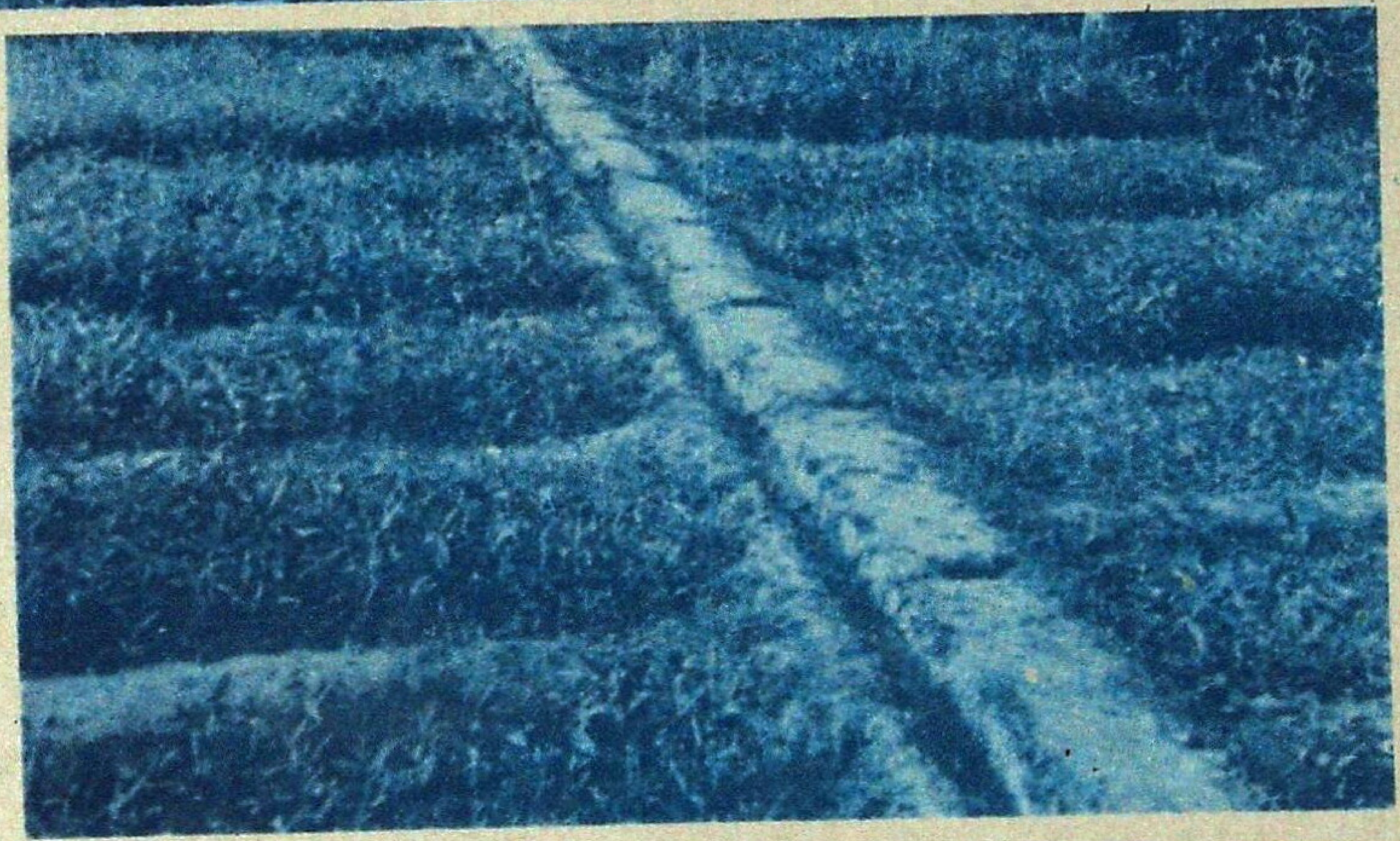

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